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THE TRANSPLANTATION OF SKIN AND SUBCUTANEOUS TISSUE TO THE HAND

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THE surgeon who transplants skin and subcutaneous tissue is indebted to many men whose experiments and discoveries have made possible the results which he accepts today as a matter of course. It is fitting that we should pause and pay our tribute to the surgical pioneers to whom we are so greatly indebted; and it is interesting to inquire what sort of men these individuals were whose names have been upon our tongues so often, but concerning whose lives and personalities so little is recorded.

As with many surgical procedures the origin of the idea of transplanting tissues from one part of the body to another is shrouded in mystery, but it dates back many centuries. In some of the earliest records,[1] it is said, the restoration of the nose by the use of pedunculated flaps from both forehead and cheek is referred to as a well recognized procedure; and it is probable that the desire for restoration of form as well as function was as dominant an impulse in the injured East Indian and Egyptian of 5000 years ago as it is in the war veteran and glamour girl of today.

Celsus, Galen, and other writers of the first centuries after Christ described the repair of defects of ears, noses, and lips by the aid of flaps from the adjacent tissues; and then followed a hiatus of centuries, as far as progress in the transplantation of tissue is concerned, before the appearance of a small volume, *De curtorum chirurgia per insitionem* (Surgery of the Mutilated by Grafting) (Fig. 1), in 1597

From the Division of Surgery, Northwestern University Medical School. Read before the Minneapolis Surgical Society, Minneapolis, Minnesota, February 1, 1940.

[1] ". . . . plastic surgery was practiced in ancient India and Egypt, as is shown by the sacred writings of India, and in Ebers' *Papyrus*, in both of which rhinoplasty is mentioned as a well-known procedure." (*Plastic Surgery*. J. S. Davis, p. 1.)

The first part of this statement is correct. In the *Sushruta Sanhita* (200 B.C.–300 A.D.) the surgeon is advised to repair the defective lobe of the ear with a "patch of living flesh from the cheek . . . . with one of its ends attached to its former seat," and to repair the injured nose with "a patch of living flesh . . . . sliced off from the region of the cheek."

In *Commentaries and Annotations on the Sushruta Ayurveda* F. Hessler quotes (*Die Literatur und Geschichte der plastischen Chirurgie*, p. 59): "The careful doctor takes [as a pattern] the leaf of a plant the size of the nose, cuts a flap from the cheek according to the pattern laid upon it, but leaves the flap attached at one place. He quickly puts the [new] nose in place after he has incised the edges, fastens it in the proper position with a good bandage, carefully inserts two small tubes of appropriate size [as breathing spaces], elevates it, and strews over it dust of red sandalwood, sweet wood and antimony. Then he covers it with white cloth and moistens it often with oil of sesame . . . .

"When the transplanted flap is united the pedicle is divided. If the nose is too small one attempts to make it grow; if it is too large one reduces it to the proper size."

A careful reading of Cyril P. Bryan's and of B. Ebbell's translations of the German version of the *Papyrus Ebers* (early sixteenth century, B.C.) reveals no mention of rhinoplasty nor of any surgical procedure remotely resembling it.

Bryan states (page 76), "Skin grafting, it may be shortly said, formed no part of the accomplishments of the medical practitioner in Ancient Egypt"; and Ebbell says (p. 17), "Suturation is not mentioned at all so it has surely not been used."

In the Edwin Smith Surgical *Papyrus*, a seventeenth century B.C. copy of a treatise written in the Pyramid Age (3000–2500 B.C.) 48 surgical cases, representing lesions of the upper half of the body, are discussed in considerable detail. Here also no mention is made of skin grafting or transplantation of tissue.

again focused the attention of the surgical world on this problem.

One could point many a moral from the stir created by this volume—the far-reaching importance of the discovery of printing, the forceful stimulus of war and pestilence to surgical progress, the value of illustrations in medical and surgical literature, the homage that is often given to the man who first records for mankind rather than to him who conceives a new idea but fails to tell it to the world in a voice that can be heard.

Gaspar Taliacotius or Tagliacozzi (1546–99) of Bologna (frontispiece), the author of the book in question, lived in the stirring years that followed the discovery of the New World. He studied at the University of Bologna under Jerome Cardan (Geronimo Cardano), best known for his treatises on arithmetic, algebra, and natural history. He received the degree in philosophy and medicine at the age of 24. Six years later he was admitted to membership in the college of medicine and became a professor in the University of Bologna. Wars, disease, man's inhumanity to man brought him abundant opportunity for the exercise of his surgical skill. In one of their satirical essays in the *Tatler*[1] Addison and Steele stated (though obviously in jest) that Taliacotius at one time had as patients under his care 12 French marquises, 20 German counts, 100 Spanish noblemen.

Taliacotius' work is divided into two books. The first includes an elaborate introduction with references to the poets, the fathers, and the scriptures; a discussion of the principles involved in the transplantation of tissue; a theoretical consideration of the choice of tissues to be used in the restoration of ears, lips, and noses; and, in the nineteenth chapter, references to the work of Galen, Celsus, Paul of Aegina, of Alexander Benedictus, and of his contemporaries—Fallopius, Vesalius, Paré, and Schenk. In the second book the repair of defects of the nose with the aid of a delayed pedunculated flap from the arm is described in detail. The instruments required, the technique of the operation, the duties of the surgeon's assistants, and the postoperative care of the patient are discussed at length.

[1]Number 260. December 7, 1710.

Twenty-two beautiful woodcuts by Francesco Capello of Modena, a decorator of churches and an illustrator of books, picture the various steps of the operation and the apparatus used to hold the arm immobilized alongside the nose while the transplanted flap is developing a new blood supply (Fig. 2).

Although Taliacotius is often referred to as the originator of the Italian method of rhinoplasty his own writings indicate that the principles involved had been recognized long before and that the operation as he performed it had been practiced for more than a century. Records dating back as far as 1442 mention Branca, a Sicilian surgeon, as practicing a method for replacing defects of the ears, lips, and nose; and his son Anthony is referred to as "a celebrated surgeon who restored ears, lips, and noses." Vincent Vianeus, also called Vioneus, Boianus, and Boiani, a surgeon of Tropaea, together with a nephew Bernard, and the latter's son Peter, who died in 1571, were also distinguished for repairing defective lips and noses.

Alexander Benedictus, a native of Legnano who taught medicine in Padua before 1495, has left a record of the technique of rhinoplasty which was published in 1497, exactly 100 years before the appearance of Taliacotius' work.

"In our time, skilful persons have taught us how to rectify deformities of the nose. Portions of flesh, cut from the arm of the patient, formed into the shape of nostrils, and added to the trunk of the nose, are very commonly seen. They dissect the upper skin of the arm with a razor; and, then, paring off the remaining edges of the nostrils, or, if necessary cutting them away, they bind the arm to the head, in order that wound may adhere to wound. After this, the wounds having conglutinated, they take away from the arm, with the knife, as much as is wanted for the restoration of the nose, which they accomplish; for the kindred vessels of the nose nourish the flesh which is newly acquired, while hairs sometimes grow on the skin, because of its origin on the arm. In this manner, with admirable art, new noses are formed, with open nostrils; and, with a bold ingenuity, nature is subjected to our will. It is to be added, in the mean time, that these artificial noses badly endure a severe winter; and, further, I warn persons to use them gently, lest they be torn away from the trunk."

Fallopius, who died in 1563, also described the operation; Paré referred to it in 1561; and

GASPARIS
TALIACOTII
BONONIENSIS,
PHILOSOPHI ET MEDICI PRAECLARISSIMI,
Theoricam ordinarium, & Anatomen in Gymnasio Bononiensi publice profitentis
De Curtorum Chirurgia per Insitionem,
LIBRI DVO
In quibus ea omnia, quæ ad hanc Chirurgiæ, Narium scilicet, Aurium, ac labiorum per
insitionem restaurationem cum Theoricen, tum Praxim pertinere videbantur, clarissima methodo communi sensui declarantur.
Addita Cutis Tradacis instrumentorum omnium, atque deligationum
Iconibus, & Tabulis
Cum indice quadruplici copiosissimo, Capitibus singulorum librorum, Anatomes, Commentariorum,
Rerum denique & plurimis memorabilium.
Cum Paralegys Summi Pontificis, Collegii Medicorum, Chirurgorum, Collegii, & aliorum Principum,
Hispaniarum, Senatus Veneti, & aliorum Principum.
VENETIIS. M D XCVI.
Apud Gasparem Bindonum iunior.

Fig. 1. Title page of the first edition (Bindonus edition) of Taliacotius' *De Curtorum Chirurgia per Insitionem.*

36 CHIRVRG. CVRT.

Icon Decimaseptima.

Fig. 2. Illustration from Taliacotius' *De Curtorum Chirurgia per Insitionem,* illustrating his method of immobilizing the upper extremity beside the head.

Vesalius in his *Chirurgia Magna* (1569) discussed the problem of restoration of the nose and gave an imperfect account of the operation.

Although Taliacotius acknowledged his indebtedness to those who had gone before him his comprehensive discussion of the problems involved and his accurate and beautifully illustrated description of the operation of rhinoplasty entitle him to the honored place he holds in surgical history.

At his death at the age of 53 years, November 7, 1599, the magistrates of Bologna placed a statue in his honor in the anatomical theatre of the University, and the faculty a marble tablet with the following inscription:

"To Gaspar Taliacozzo, citizen of Bologna, and a celebrated philosopher and physician of his age, well acquainted with the anatomy of the whole human body, which he frequently dissected before a public assemblage of the most learned men, and demonstrated with admirable eloquence, method, and doctrine, pouring light upon the most obscure parts. Readers and Medical Professors! the Faculty of Bologna, in testimony of their gratitude, and to perpetuate the remembrance of it, have raised him this monument."

It is said, however, that after his burial in the church of St. Giovanni Battista voices were soon heard proclaiming "Taliacotius is damned," and that to prevent desecration of hallowed ground his body was exhumed and cast into the outer darkness.

In the years following Taliacotius' death, because of the influence of the clergy, who "considered such operations as meddling with the handiwork of God" (Garrison), and the interdiction of face repairing by the Paris Faculty in 1788, plastic surgery fell into disrepute and not until the nineteenth century did definite progress again take place. In the meantime Taliacotius' teachings were forgotten and if they were sometimes recalled to mind it was with doubt as to their truth, with misrepresentation and often with ridicule.[1]

In the nineteenth century, along with the progress that took place in many phases of medicine and surgery, interest in the transplantation of tissue was revived; and this awakening was due both to a revival of interest in the teachings and achievements of Taliacotius and his contemporaries and to a belated recognition of the fact that in India for many years, perhaps centuries, members of the potters' caste had repaired the ravages wrought by brutal warriors and potentates, and restored noses and lips with the aid of pedunculated flaps from the forehead. In 1816 Carpue, a London surgeon, published an account of 2 cases of restoration of the nose by the Indian method,[2] and a few years later in Germany Dieffenbach (1792–1847) began his "pioneer (work) in transplantations and experimental surgery on animals first essayed by John Hunter and Guiseppe Baronio" (Garrison). The renaissance of plastic surgery thus begun reached its climax in the war years of 1914–1918.

The free transplantation of skin, as contrasted with the use of pedunculated flaps is a development of the nineteenth century. Although it has been said that in India the restoration of the nose with free grafts of skin and subcutaneous tissue was successfully accomplished I have been unable to find any definite record of it; and if it was actually carried out it remains an achievement that the surgeon of today has not been able to equal.

Of the men whose names have become associated with the transplantation of free grafts of skin—Reverdin, Lawson, Ollier, Thiersch, Wolfe, Krause—none of them probably would have considered himself a plastic surgeon, or thought that his contribution to the subject of skin grafting would prove a "float through posterity."

Although as early as 1804 Baronio successfully carried out in animals free transplantation of pieces of skin as large as 12.5 by 7.5 centimeters in size, and although a partially successful transplantation of skin was reported by Dieffenbach in 1824[3] the first report which attracted the attention of the medical world was by JAQUES-LOUIS REVERDIN in 1869. On December 8th of that year he demonstrated to the Société Impériale de Chirurgie a patient on whom he had successfully carried out skin grafting with "two small bits of epidermis raised with the point of a lancet from the patient's right arm."

Reverdin (1842–1929) was born in Geneva of a distinguished family whose forebears fled from France in 1709 to escape religious persecution. His grandfather was an artist and professor of design in the municipal college, his father a distinguished architect, his maternal grandfather a physician and naturalist. At the age of 20 he received the degree of bachelor of arts at the Academy of Geneva, 2 years later the degree of bachelor of science and immediately afterward began the study of medicine in Paris. In the *concours* of 1865 he received the coveted appointment of *interne des hopitaux* and for 4 years continued his studies in the hospitals of Paris. In 1869 he was awarded the gold medal of the *concours de l'internat*[4] for his study upon the gravity of anthrax and of furuncles of the face, and the privilege of continuing his

[1]Carpue points out that in the eighteenth chapter of book one of *De Curtorum Chirurgia* Taliacotius discussed the question of taking a flap from the arm of another person; and although he thought there was no reason to doubt that the skin of one man would unite with that of another he considered the operation impracticable and asserted it had never been practiced. The same credulity which inspired the jests of wits and poets, and the tales of noses formed from the tissues of another person, which mortified when their donor expired, still persists in this modern world.

[2]This beautifully printed small quarto volume, illustrated with a number of engravings by Charles Turner, contains a well authenticated account of the history of the Italian and Indian methods of rhinoplasty. I am indebted to Carpue for many of the facts recounted concerning Taliacotius and his work.

[3]Eduard Zeis in *Die Literatur und Geschichte der plastischen Chirurgie* (page 47) cites the following report of Johann Friedrich Dieffenbach from Graefe and Walther's Journal, 1824, vol. 6, page 482.

"In the case of an old woman whose left arm was completely anesthetic Dieffenbach cut two dollar-sized pieces of skin and exchanged them. One shrivelled; the other was inadvertently torn away with removal of the bandage on the sixth day, whence it followed that one part of it had already become united with the floor [of the wound] by means of connecting reddish cellular tissue."

[4]Competitive examination of the resident group.

studies on the service of his choice. The following two years were spent on the surgical service of Dolbeau and Gosselin[1]; and during this period, in 1870, he acted as surgeon in chief of the ambulance established by the Swiss colony of the besieged city. During this period, also, Guyon, the distinguished urologist, presented in his behalf the report, referred to above, of Reverdin's experiments with small grafts, carried out on Guyon's service at l'Hôpital Necker.

In 1872, following the completion of his *internat*, in spite of the urgings of his teachers and the attractions of a surgical career in Paris, Reverdin returned to his native Geneva. Two years later he was appointed associate surgeon at the hospital of Geneva, and in 1876, chief surgeon. The same year he was appointed professor of external pathology and of operative medicine in the Faculty of Medicine, and for 34 years thereafter without interruption continued his work as a teacher.

In 1879 with his cousin, Auguste Reverdin, he founded a surgical clinic—an unusual venture, for specialization even in general surgery was still uncommon. In 1881 with Picot and Jean Louis Prevost he founded the *Revue médicale de la Suisse Romande* and for 38 years as editor and contributor continued to take an active interest in it.

Like every Swiss surgeon he was greatly interested in thyroid disease, a condition endemic in Switzerland. He had often noted in his patients the development of tardy and peculiar symptoms after thyroidectomy, and in 1882 he presented the results of his observations to the Société Médicale of Geneva, suggesting that the thyroid gland exerted an influence on the body hitherto unrecognized. Kocher corroborated Reverdin's observations and gave the name cachexia strumipriva to the symptom complex described by Reverdin.[2]

From 1882 until 1910 Reverdin continued his active clinical and investigative work. He was interested in practically every phase of general surgery and his many contributions included in addition to a number of papers on skin grafting and thyroid surgery such diverse subjects as umbilical hernia, coxofemoral disarticulation, hallux valgus, ether anesthesia, and the surgery of war wounds.

In 1910 at the age of 68 he resigned from his teaching and professional activities and devoted the remainder of his life to scientific writing and the pursuit of what had long been a favored avocation—the study of Lepidoptera. In this field also he attained distinction and became an honorary member of entomological societies of Philadelphia, London, Brazil, France, and Switzerland. He died "full of years and honors" January 9, 1929.

Reverdin's original paper on the subject of skin grafting appeared in the *Bulletin de la Société de Chirurgie*, December 15, 1869. He had previously noted the occasional spontaneous development of small islands of epithelium at the center of a raw surface, and the rapidity with which epithelization extended peripheralward from such islands. This observation led to the idea of hastening the healing process by the actual application of such islands over the granulating surface. The case reported was that of a man of 35 years who had sustained on October 16 an avulsion of skin and subcutaneous tissue from the left upper extremity from elbow to mid-forearm.

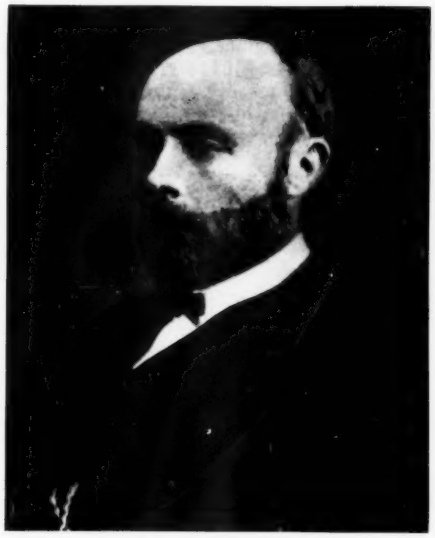
"On November 24th I raised with the point of a scalpel two small bits of epidermis from the patient's right arm. . . . The first was very small, the second nearly a millimeter square, the small wound [at the donor site] showed only red oozing. I placed my two fragments in the middle of the wound, their deep surface in contact with the granulations, at a little distance from one another, and held them with a diachylon bandage. . . . The following day the fragments were still in place in spite of very abundant suppuration; they appeared a little swollen and paler."

Three days later a third graft of 3 or 4 square millimeters was applied to the wound.

[1]Both men were keenly interested in the subject of infections of the hand. Gosselin maintained that deep infection invariably extended along the tendon sheaths; Dolbeau contended that it frequently resulted from extension along the lymphatics. Their discussions were often bitter and acrimonious. Both were right.

[2]Considerable controversy arose as to who deserved priority for the recognition of the relation between removal of the thyroid and postoperative myxedema, and the fact that the postoperative condition is identical with that resulting from aplasia of the thyroid, described by Gull in 1873. Machard says that Reverdin deserves the credit and that this fact was emphasized at the Conference International du Goitre at Berne in August, 1927. Osler says, "Kocher in 1883 reported that 30 of his first 100 thyroidectomies had been followed by a very characteristic picture, to which he gave the name 'cachexia strumipriva,' an observation which had already been made in the previous year by the Reverdins, who also had recognized the relation of this change to the disease known as 'myxœdema.' "

J. L. REVERDIN
(*Revue méd. de la Suisse Romande*, 1929, 49: 114.)



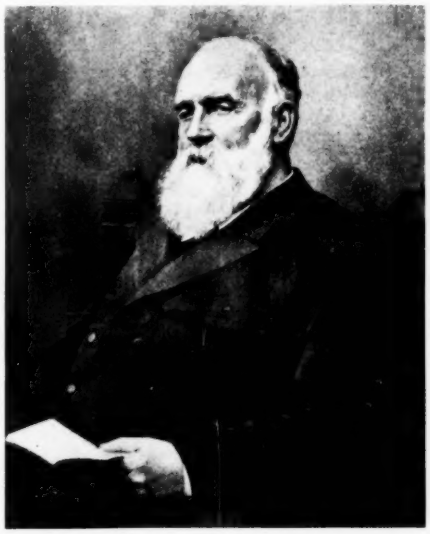
GEORGE LAWSON
(*Brit. M. J.*, 1903, 2: 1019.)

On December 1st the first two grafts had united as a result of the outgrowth of epidermis from their free margins. During the following days the epidermis continued to extend from the margin of the united grafts and from the margin of the third, and on December 7 they were united and formed a small white island exactly analogous to the border of epidermis which forms at the margins of a wound.

LOUIS X. E. L. OLLIER
(Frontispiece, *À la mémoire de Professeur Ollier*. Valence: Céas, 1906.)

Reverdin's observations attracted wide attention, by no means entirely favorable, for the possibility of erysipelas developing at the donor site was suggested as a serious danger. Nevertheless his method was promptly utilized by other European surgeons. On November 11, 1870, less than a year after the appearance of Reverdin's report, G. D. Pollock reported before the Clinical Society of London 16 cases in which Reverdin's method had been utilized in an effort to secure healing of raw surfaces with the aid of small grafts. Of the 16, 8 were successful, 2 partially successful, 6 were failures.

Immediately following Pollock's report is a brief paper which deserves attention, "On the Transplantation of Portions of Skin for the Closure of Large Granulating Surfaces" by GEORGE LAWSON, read November 11, 1870. With his paper Lawson presented 2 of 3 pa-



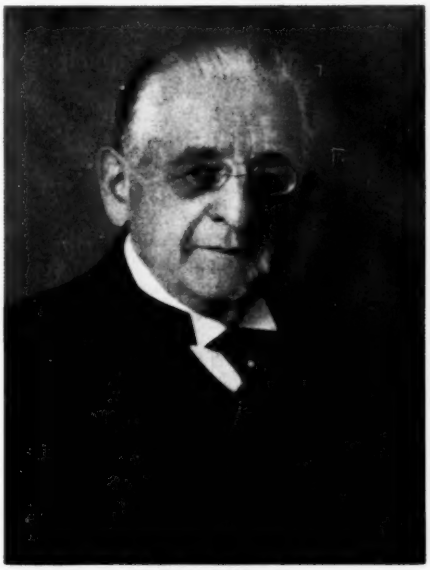
CARL THIERSCH
(Frontispiece, *Carl Thiersch: sein Leben*, by Justus Thiersch. Leipzig: Barth, 1922.)

J. R. WOLFE
(*Chicago Clin. Rev.*, 1893–94, 3: 113.)

tients on whom operation had been carried out. In the first patient with a large varicose ulcer of the leg he "transplanted a portion of skin from the inner side of the arm." In the second patient with a varicose ulcer 3 by 1¾ inches, he "transplanted a piece of skin from the inner side of the arm of the size of a four penny piece. . . . The new skin very shortly united, and granulations rapidly sprang from its circumference which closed the wound in about 18 days from the time of its transplantation." In the third case an ectropion of the upper lid was freed, the tarsal edges of the lids united, and 3 days later a piece of skin the size of a silver three penny piece "which I removed with a pair of scissors from the inner side of the arm" laid on the nasal side of the lid, as at that spot the granulations looked most vascular and healthy.

In his conclusions Lawson states,

"The cases which I have related show that pieces of skin of the size of a sixpence can be easily engrafted on granulating surfaces; it remains for experience to decide how much larger portions can with safety be transplanted, and what are the conditions under which these transplantations can be most satisfactorily conducted. When once these facts are thoroughly ascertained, the present treatment of burns, and of deformities arising from a large destruction of skin, will be completely changed. We shall no longer allow extensive granulating surfaces



FEDOR KRAUSE
(*Zentralbl. f. Neurochir.*, 1938, 2: 121.)

to be closed over by an indrawing of the surrounding skin, but we shall freely transplant portions of skin from those parts of the body where there is a redundancy. . . . The conditions which seem to me essential for the grafting of large portions of skin are—

"1. That the new skin should be applied to a healthy granulating surface.

"2. That skin *only* should be transplanted, and that special care should be taken that there is no fat adherent to it.

"3. That the portion of skin should be accurately and firmly applied to the granulating surface.

"4. That the new skin should be kept in its new position without interruption. . . .

"Lastly.—I would mention that the new skin thus engrafted, not only soon becomes vascular, but it acquires sensibility."

Although his name is rarely mentioned in connection with the transplantation of skin Lawson's report was the first account of the successful transfer of sizeable areas of skin as compared with the small grafts suggested by Reverdin, and of whole thickness skin as well.

Lawson was born August 28, 1831. He studied medicine at King's College in London and there became a student and later house surgeon to the distinguished Sir William Fergusson. He became a member of the Royal College of Surgeons in 1852 and a fellow in 1857. In 1854 he was appointed staff assistant surgeon in the army medical corps and served for a year of the Crimean war.

"He was dispatched to Gallipoli and thence to Varna on the Black Sea. In that foul and dilapidated port he suffered from a sharp attack of typhus fever. . . . Landing in the Crimea, Lawson was with the troops at the battle of Alma, and later on at the successful repulse of the Russians by the allied forces at Inkerman. During the terrible winter of 1854–5, when disease and frost wrought yet greater havoc than the Russian arms, Lawson was in the lines before Sebastopol. The privations and horrors, both inevitable and preventable, of that disastrous siege have been often told. Anæsthetics were then in their infancy, and Lawson used to tell how his was the only inhaler in the outfit of the whole Third Division."

In 1855 he contracted typhoid fever, which nearly proved fatal, and was finally invalided home. He resigned his army commission the following year. The same year he was appointed to the surgical staff of the Middelsex Hospital, and "served that institution with unstinted devotion for 33 years."

In 1862, after serving as assistant to Bowman, he was appointed to the staff of the Royal London Ophthalmic Hospital at Moorfields and continued to serve with distinction as ophthalmic surgeon until 1891. During this period he contributed a number of important papers to the Reports of the hospital and the Transactions of the Ophthalmological Society. The titles of some of these papers—paracentesis of the cornea, amaurosis during pregnancy, traumatic cataract, atropine irritation, primary epithelioma of the eyelid, tumors of the optic nerve—indicate the breadth of his scope and industry. So interested was he in the subject of sympathetic ophthalmia that it became a tradition at the Middlesex Hospital that no matter what the subject with which he began his lecture he invariably concluded with a discussion of sympathetic ophthalmia. His textbook on *Injuries of the Eye, Orbit and Eyelids*, published in 1867, was considered a classic on the subject and his book on *Diseases and Injuries of the Eye*, first published 2 years later, passed through numerous editions.

"As a general surgeon Lawson was both courageous and painstaking; fearless in undertaking any operation, however formidable if in his sound and sagacious judgment he had satisfied himself of its wisdom and justification. Though conservative by instinct he was a reformer in matters of hospital construction and in his scrupulous regard for cleanly surgery. . . . He was one of the first to discard the time-honoured frock coat, soiled with the blood stains of a hundred operations, in favour of a washable overall."

His outstanding ability as teacher and surgeon, his constant thoughtfulness and kindly personality brought him both the admiration and devotion of his house surgeons, dressers and assistants. His patients, many of them from the poorest districts of London, had frequent occasions to recall the thoughtfulness and generosity that enhanced his surgical skill and judgment. "Not a few of the blind and the halt and maimed were sent from his outpatient desk . . . to a neighbouring butcher with whom he had a running account for four pounds of beef."

In 1886 he was appointed Surgeon-Oculist to Queen Victoria, and on retiring from the active staff of the Middlesex and Moorfields Hospitals he was elected consulting surgeon to both institutions.

Toward the end of his life a marked hypertrophy and dilatation of the heart resulted in serious circulatory deficiency and edema of the lower extremities, and for the last 18 months of his life he was confined to his armchair and never went to bed, so that the Southey tubes inserted in the subcutaneous tissues might drain properly. He died on October 12, 1903.

One of his five sons, now Sir Arnold Lawson, followed closely in his father's footsteps, and as an outstanding ophthalmologist has added still further distinction to the family name.

Like Reverdin, LOUIS XAVIER EDOUARD LEOPOLD OLLIER (1830–1900) came from a family with a background of scientific interest and achievement. Among his ancestors were a grand chancellor of the University of Toulouse, a number of magistrates, and four generations of physicians. His father was a physician in Vans in the department of Ardèche, where Ollier was born on December 2, 1830. A brother, a cousin, and two nephews were practitioners of medicine.

Ollier began the study of natural science at Montpellier, studied medicine at Lyons, and served as interne in the hospitals of Lyons. He received his doctor's degree at Montpellier in 1856. The following year, attracted by the great name of Claude Bernard and interested in the problem of growth and reproduction of bone as a result of the influence of his teacher, Bonnet, he went to Paris to attempt to settle the question of the osteogenetic function of the periosteum.

The dispute as to the bone forming power of periosteum was at its height. Duhamel, a young Frenchman, not a physician, had repeated the experiments of Belchier, the English surgeon, and noted the effect of feeding bran, soaked with madder, on the bones of fowls and pigs. He had noted that the layer of bone stained by the madder lay immediately under the periosteum and that an animal fed alternately with dyed and undyed food formed alternately red and white layers of cortical bone. Duhamel's observations were confirmed by the "brilliant experimental physiologist, the handsome courteous clever and conceited Marie Jean Pierre Flourens" (Keith, *Menders of the Maimed*, p. 130), but were vigorously contested by Albrecht von Haller, the Swiss professor of anatomy at the University of Goettingen "the master physiologist of his time" (Garrison). Haller had concluded from his experiments and observations that bone was a product of the arteries "which could lay down bone anywhere—within cartilage or beneath the periosteum."

Ollier began his own experiments by raising a flap of periosteum from the surface of the tibia of a young rabbit, leaving the flap attached at its base and turning the free end of the flap over the deep flexor muscles of the leg. In six weeks the flap had become a loop of bone. He continued with other experiments, twisting the base of the flap to compress its blood vessels, dividing the pedicle three days after raising the flap, and finally transplanting free grafts of periosteum into the subcutaneous tissues of the thigh. In each case new bone was formed at the site of the transplant. He "entered Chauveau's laboratory a sceptic; when he had completed his first series of experiments he was convinced of the osteogenetic properties of periosteum."

In 1860, at the age of 30, he was called to the chair of clinical surgery at Lyons and appointed senior surgeon at the Hôtel-Dieu. After eight years of patient experimental investigations—on the periosteum, on the medulla, on the bone itself, on the effect of experimental fractures, on the effect of injury to the epiphyseal lines of growth—he published the results of his observations in two volumes entitled *Traité expérimental et clinique de la régénération des os et de la production artificielle du tissu osseux*, a classic on the subject of growth and development of bone.

Throughout his long career as professor of surgery at Lyons he continued his experimental and clinical studies with unflagging interest and energy. In a memorial written by Eugene Vincent in the *Archives provinciales de chirurgie* the list of contributions to surgical literature made by Ollier or inspired by him in the years from 1868 to 1900 occupies eleven pages. Almost one hundred of them were contributed by Ollier himself.

He died on November 25, 1900, in his seventieth year, in the midst of a family

reunion and only twenty-four hours after he had performed a number of operations at the Hôtel-Dieu and made the rounds of his surgical service. He had received almost every honor the surgical profession of his own and other nations could bestow upon him.

Ollier's contribution to the subject of skin transplantation appeared in 1872 in the *Bulletin de l'Académie de Médécin* under the title "Greffes cutanées ou autoplastiques." He went much farther in his conception of the problem than Reverdin, for he did not simply attempt to create new islands in granulation tissue from which epithelium might grow but carried out complete excision of scar tissue and its replacement with skin. He specifically stated that he used large grafts "4, 6, 8 centimeters square, and larger, including not only the superficial layers of the skin but the entire derma"—"*comprenant non seulement les couches superficielles de la peau, mais la totalité due derme.*" For two years previous to his use of such "*dermo-épidermiques*" grafts he had used strips containing only a part of the derma, "*lambeaux comprenant qu'une partie du derme*"; and in this respect also he had gone farther than Reverdin, but he favored grafts of whole thickness skin (*toute l'épaisseur de la peau*) for "*. . . les resultats lui paraissent devoir être plus complets et plus persistants par la transplantation de la totalité du derme comme il la pratique aujourd'hui.*"

One cannot read Ollier's paper carefully without realizing that he deserves credit for the first description of the graft of intermediate thickness, and that he shares with Lawson the credit for the initial successful use of the graft of whole thickness skin. Finally, it is interesting to note that he laid a free graft of periosteum from an amputated leg over a granulating surface, for he considered the connective tissue as the active element in the growth of a graft. We do not know the result of this procedure but it indicates that his interest in the transplantation of skin was closely related to his long continued study of periosteal transplants and bone growth.

Carl Thiersch (1822–1895) belongs to the distinguished group of men who were responsible for the high esteem accorded to German medical science during the last half of the nineteenth century. He was born in Munich April 20, 1822, studied there, and received the degree of doctor of medicine in 1843. After four years of study in Berlin, Vienna, and Paris he returned to Munich. In 1848 he was appointed prosector in pathological anatomy, and in 1853 professor. In 1850 he served as a volunteer surgeon in the second Schleswig-Holstein campaign and during that interval was greatly influenced in his surgical outlook by Stromeyer, "the father of modern military surgery in Germany" (Garrison).

In 1854 he was appointed professor of surgery at Erlangen and in 1867 to the chair of surgery at Leipzig. The years that followed constituted the golden age for the University of Leipzig. Carl Ludwig had become professor of physiology 2 years before; Wilhelm His came from Basel 5 years later. The tribute of His to his two great contemporaries, published in the *Akademische Gedachtnisrede* and translated in Appleton's *Popular Science Monthly*, is a graphic portrayal of the two men and of their contribution to Leipzig and to medical science.

Thiersch was a pioneer apostle of fresh air and sunshine in the treatment of surgical patients. The Jacob's Hospital, built under his direction, was the first hospital in Europe constructed on the pavilion or barrack plan. Air and light, he said, are "unpaid but invaluable assistant physicians." Lister's paper "On the Antiseptic Principle in the Practice of Surgery" it will be recalled, was published in 1867, the same year that Thiersch was called to Leipzig. Thiersch was quick to recognize the importance of Lister's contribution and became one of his strong protagonists.

"When, soon after the opening of the hospital in 1871, Lister's beneficent methods of surgical treatment were made public, it was again Thiersch who at once recognized their enormous significance, and advocated them with all his power. This beautiful hospital afforded him the best possible conditions for the carrying out and further development of the newly acquired methods, as well as for their introduction in the education of the younger medical generation. There he worked during the past twenty-four years, not only as a teacher revered by all, but also as a faithful physician; and he so loved his hospital that even during his time of suffering he occu-

pied himself ceaselessly with it, and one of the last wishes he expressed was that he might be able to return there once more." (Wilhelm His, *Carl Ludwig and Carl Thiersch.*)

Thiersch's most important contributions were his monograph on epithelial cancer, his treatise on wounds and wound healing and on the transplantation of skin. His first paper was presented before the third Congress of the Deutsche Gesellschaft fuer Chirurgie April 9, 1874. He had utilized for experimental transplantation of skin an extensive ulcer of the leg of four years' standing, recurring in its entire extent after healing had once been secured with the aid of Reverdin grafts. Over this extensive ulcer he had applied centimeter square grafts at periods varying from 3 weeks to 18 hours before amputation. The amputated leg was injected with Gerlach's injection mass and the grafts studied with the help of fine sections stained by various methods.[1] Thiersch was able to demonstrate the vascularization of the agglutinated grafts as early as 18 hours after their application by "intercellular ducts which are immediately fed with blood from the granulation vessels and carry it into the vessels of the engrafted skin and back again." In the course of a few days, he stated, a few of the ducts were transformed into blood vessels while the remainder were obliterated. He noted that frequently the superficial portion of the graft became necrotic and sloughed, and that the deeper retained portion contained sweat glands. It was from these sweat glands, he assumed, that epithelium sometimes developed 1 or 2 weeks after apparently complete loss of the graft had taken place.

Thiersch recognized the fact that soft hypertrophic granulations formed an unsatisfactory bed upon which to lay a graft, and that even if healing took place the healed surface was incapable of withstanding trauma and often gave way as a result of slight injuries.

"Can this disadvantage be eliminated? Perhaps. In the perpendicular section of the granulating tissue two definite layers can be distinguished: the underlying one with rather tensely drawn connective tissue, and above it a horizontally placed network of vessels. From this horizontal stratum of vessels and tissue, the much softer granulations, richly supplied with vessels, develop in perpendicular direction.

"If this portion becomes incapable of transformation into scar tissue, i.e., if the soft granulations, with their wealth of vessels, are not transformed into rigid, narrow scar papillæ, with few vessels, the reopening of the granulation closed by the skin graft is only a question of time. The only alternative, therefore, is elimination of the superficial portion of the granulation and implantation of the skin directly upon the tense underlying tissue. This substratum is exposed by sharp, horizontal incision, hemorrhage is permitted to run its course completely, and then the skin graft is placed upon this fresh wound surface, whose vessels and tissues are in excellent condition for immediate inflammatory adhesion."

In later papers (1886, 1888) Thiersch advised cutting or scraping off granulation tissue down to the firm underlying tissue before applying grafts over a granulating surface, cutting grafts with a razor blade in lamellæ as thin as possible from the patient's own skin, and placing the grafts with overlapping edges to avoid scar formation. In preparing the field of operation he considered antiseptics a disadvantage and used only physiological salt solution.

His use of a graft to line a flap from the temple, intended to replace the upper lip, and of a graft to cover an extensive defect of the temple left after raising a pedunculated flap to cover the eyelids, the side of the nose and cheek indicates to what an extent he had visualized the possibilities of transplantation of skin.

John Reissberg Wolfe (1824–1904), like George Lawson, was an ophthalmic surgeon. He was born in Breslau but received his medical education at Glasgow University and the degree of doctor of medicine in 1856. After serving for some years as ophthalmic surgeon at the Royal Infirmary at Aberdeen, he returned to Glasgow and founded the Ophthalmic Institution in West Regent Street. When the St. Mungo's College Medical School was organized Wolfe became the first professor of ophthalmology.

After practicing with distinction for some years he moved to Melbourne, Australia, in 1893 and continued in the practice of his

[1] In an obituary notice in the *British Medical Journal* (1895, ii, 1360) it was noted that Thiersch was a most dexterous microscopist, and that when section cutting and staining were in their infancy he supplied Smith and Beck of Cornhill with marvellous slides of injected and stained specimens of normal and pathological tissues.

specialty there for 8 years. He returned to Scotland in 1901 and died in Glasgow.

Wolfe's first report of the use of whole thickness skin as a graft appeared in the *British Medical Journal* (1875, 2:360). He said:

"Tagliocozzi laid down the rule, which has ever since been considered as the primary law and *sine qua non* to the success of the operation, that the flap must retain its connection to the adjacent living structure by a pedicle which is to be severed only after complete union and cicatrisation of the raw surfaces. This pedicle has, in my opinion, been a source of great embarrassment to surgeons, and tended rather to retard the progress of plastic surgery. From my observations on transplantation of structures from the lower animals and on skin-grafting, as well as on plastic operations, I have long held it demonstrated, that in most cases the pedicle is not essential, if indeed it do contribute anything, to the vitality of flap. This being once established, we are henceforward free to choose our bit of skin from any part of the body we may find suitable.

"My next endeavour has been to eliminate the elements of failure. The principal cause of failure I find to be in the subcutaneous structures. If we wish a skin-flap to adhere to a new surface by first intention or agglutination, we must be sure that it is cleared of all areolar tissue, and properly fixed in its new place. The following case will illustrate the points referred to."

He then described the repair of an ectropion of the lower right eyelid by excising the scar, suturing the edge of the lid to the upper lid, and covering the defect, 1 by 2 inches, with a graft from the forearm. After removing the graft "as close to the dermis as compatible with the integrity of the flap," from two-thirds of the graft, "with a cataract knife I sliced off the areolar tissue leaving a white surface." This part of the graft remained viable and healed without loss. ". . . . that part which was applied without previous preparation looked rather livid the first day, improved the next two days; the fourth day, it began slightly to suppurate; and, after a hard struggle for life, a portion of it only remained, while the rest shrank."

Wolfe's essential contribution, as indicated by the above quotation, was his insistence that all the subcutaneous tissue should be removed and that the graft should consist only of skin, a point that had already been emphasized by Lawson (p. 8). On so slender a foundation does the name "Wolfe-Krause" graft rest.

FEDOR KRAUSE (1856–1937) who died only 3 years ago, was both a general surgeon and a neurologic surgeon. He studied in Berlin, Halle, and Frankfurt am Main and graduated at Berlin in 1879. Subsequently he worked in the ophthalmological clinic of Julius Hirschberg, under Robert Koch at the Imperial Board of Health and under Weigert at Frankfurt. From 1883 to 1889 he was an assistant of Volkmann at Halle, was appointed a resident instructor in 1887 and professor in 1889. In 1892 he was appointed chief of the surgical division at the municipal hospital of Altona, and in 1900 chief surgeon of the Augusta Hospital in Berlin.

"Graduated from the school of Richard v. Volkmann in Halle the same creative strength and the same artistic fervor bound him to his honoured preceptor. Endowed with a personality of sparkling vitality and associated with a distinguished and gifted preceptor during a period of rapid surgical progress he knew how to value these gifts and this good fortune" (Behrend).

His scientific interests included such widely separated fields as ophthalmology, bacteriology, tuberculosis of the bones and joints, and plastic surgery. His outstanding contributions, however, were in the field of neurologic surgery. His inaugural thesis (*Habilitationsschrift*) in 1887 was on the subject of malignant neuroma. In 1896 he published his monograph on trigeminal neuralgia and on the anatomy and histology of the trigeminal nerve. Four years before he had first devised the extradural approach to the gasserian ganglion through a bone flap raised from the temporal region, and this approach, carried out almost at the same time by Hartley of New York, was the essential factor in transforming what had been a difficult and dangerous operation into a relatively simple and safe procedure. Although Krause considered extirpation of the ganglion the operation of choice in the treatment of neuralgia Behrend states that he had described preganglionic division of the nerve before the publication of Frazier and Spiller's paper on physiologic extirpation of the ganglion of Gasser in 1904.

In 1898, to relieve a patient suffering from an intractable tinnitus aurium he exposed and divided the auditory nerve by an approach through the posterior cranial fossa, and so laid the foundation for the surgical removal of tumors of the cerebellopontine angle. In a similar way the removal of a bullet from the roof of the right orbit just above the optic foramen in 1900 led to the transfrontal approach to the hypophysis.

At a time when the results of operation for brain tumor were disheartening, to say the least, Krause wrote:

"The prognosis [of operations] varies according to the state of the neoplasms; the most unfavorable ones are the diffuse gliomas. . . . Perhaps some day we shall reach the point of diagnosing these infiltrating gliomas with a fair degree of certainty. . . . If this large percentage of inoperable neoplasms were eliminated from the field the operative prognosis would be essentially improved."

"We must not permit ourselves to become discouraged. Of course it requires a high degree of self-mastery to take up the knife again after a series of depressing failures in the hope that the next operation will have a satisfactory result. This field has merely been opened; the profession has freed itself from E. von Bergmann's view, to the effect that for the most part the brain tumors in the sensory-motor region are the only ones to be considered for operative treatment, but much still remains to be done."

His *Chirurgie des Gehirns und Rueckenmarks*, published in 1911, and *Allgemeine Chirurgie der Gehirnkrankheiten*, published in 1914, were recognized as outstanding and fundamental contributions in the field of neurologic surgery.

Krause's paper on transplantation of skin was presented before the twenty-second congress of the *Deutsche Gesellschaft fuer Chirurgie* April 13, 1893. After dwelling briefly on the disadvantages of the pedunculated flap and the inadequate results obtained from the use of Thiersch grafts he described the favorable results obtained from the use of more than 100 whole thickness grafts used in 21 cases of grave ulcer of the leg and of defects of the face resulting from excision of cancerous growths or lupus. Of the more than 100 grafts, some of them 20 to 25 centimeters long and 6.8 centimeters wide, only 4 were completely lost. He stated that he followed "Wolfe's procedure of using only the cutis together with the epidermis." He emphasized as matters of chief importance "complete asepsis, dry operation, and careful checking of hemorrhage, by means of compression, in the parts to be covered." He rarely sutured the graft to the margin of the defect but depended upon smooth and careful bandaging to hold it in place. The original dressing was left in place for 3 or 4 days and removed with extreme care to avoid separation of the graft. Complete healing, he stated, required from 3 to 6 weeks.

Undoubtedly Krause deserves credit for popularizing the use of grafts of whole thickness skin and emphasizing the wide indications for their use. From the standpoint both of originality and priority it would seem, however, that the graft of whole thickness should be called the Lawson-Ollier graft rather than the name by which it is referred to in most textbooks of surgery.

In paying our tribute to those who have gone before it is only right to add that every surgeon of today owes a great debt to two men who after long and successful careers are still actively interested in the teaching and practice of surgery. The contributions of Blair and Davis to the problem of transplantation of skin and subcutaneous tissue are too well known to require detailed comment. They will be referred to frequently in the concluding chapter of this paper.

EDITOR'S NOTE: The second and final chapter of this paper will appear in the next issue of this journal.

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THE SURGERY OF MODERN WARFARE

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THOSE of us who followed the literature of the surgery of warfare from 1914 to 1919 will recall the ever-increasing number of articles on every phase of this subject which appeared in medical and surgical journals of all countries involved in that catastrophe during the time of actual hostilities.

For several years after the war there appeared many articles dealing largely with the reconstructive phases of war wounds and with the application to civil practice of some of the lessons learned in that period of the mass treatment of wounds and infections. Notable among these were, débridement, the use of skeletal traction, the treatment of empyema and the Carrel-Dakin treatment of wounds. Insensibly, surgical interests have changed to the application of surgery to science which has been so important in the past 20 years, while the subject of trauma in warfare has been approached from new angles.

During all this time, minor episodes of social and political adjustments by gunpowder have occurred without marked influence on surgical thought. In 1936 the Sino-Japanese incident began to exert a slight influence and in 1937 the Spanish Civil War augmented still further, interest in the surgical aspects of newer methods of trauma. In 1939 the European political situation changed to one in which surgery faced the same old problems under new conditions of mass physical destruction and trauma. Science is said to speak a common language but with a tight political censorship, interference with communications, and the abolition of literary production, the flow of scientific ideas concerning the surgical phases of these calamities has been reduced to stagnation. The medical officers concerned with the wounded have written little, or because of political or economic difficulties have not been able to publish their observations; consequently, any review of recent achievements must be inadequate and incomplete.

A comment in the *Journal of the American Medical Association* in August, 1940 states that there has been a diminution in the receipt of medical publications coming from abroad since the end of May. The most recent shipment from Germany arrived July 22, 1940, at which time only two periodicals were received. Austrian weekly publications have not been received since early in June. Polish and Czechoslovakian journals have not been received for many months. Within the last 4 months official notification has been received of the suspension of eleven French medical periodicals, while publications from Great Britain are still being received with slight delay. In our own Medical Library, no German medical periodicals have been received since September, 1939, no Spanish periodicals since the onset of the Civil War, and no French journals have come since the occupation and very irregularly for months before. The last Scandanavian *Acta Chirurgica* arrived in April, 1940 and the *Nordisk Medicin* has not been received at all during 1940. As a consequence any review of the literature on this subject must be incomplete and lacking in factual accuracy and finality; at the best it conveys only an impression. However, a review of what has been written and what is readable has allowed a preliminary appraisal of chemotherapy, of the "closed" treatment of compound fractures and has made it obvious that changes are occurring which have revolutionized certain phases in the care of the wounded. It is further apparent that important contributions are forthcoming from this experience in a great laboratory for the study of trauma.

The indiscriminate mass attacks directed against densely populated cities coupled with the increased effectiveness of air forces have directed attention to a new problem in the present type of warfare. In addition, the

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mechanization of war with its increased mobility presents new problems in the collection and transportation of wounded. The increasing range of artillery fire combined with the mobility of the front and the ubiquity of the airplane in turn tends to decrease in type and amount the surgery permissible at the front.

Débridement. Ambrose Paré was one of the first to oppose cauterization of wounds produced by missiles projected by gunpowder. In the oft quoted phrase "he layed the ghost of poisoned wounds from gunpowder and . . . . determined never again to burn thus so cruelly the poor wounded by harquebuses."

Although as early as 1897, a German surgeon, P. L. Friedrich, published experimental work on the treatment of contused wounds as if they were neoplasms, the factor of vitality of tissues as the decisive element in infection has not been given its due importance (65, 66). In the Franco-Prussian War, only 9 per cent of the wounds were caused by shell-fire and approximately 90 per cent by bullets (43). With the development of modern warfare, the ratio has been almost completely reversed. Approximately 75 to 80 per cent of all wounds in modern war occur as a result of low velocity projectiles from artillery fire. The type of wound commonly received, therefore, is lacerated and contused, usually contaminated by foreign bodies and requires extensive débridement to facilitate its healing and to avoid systemic infection. Because of the frequency with which débridement is done, it has come to be known as "The Evacuation Hospital Operation." Evacuation hospital surgeons soon become specialists in débridement, but if their special training must be secured at the expense of the early wounded as in the last war it will be unfortunate (13). Leriche has stated also that débridement was accomplished by surgeons of the last war only after considerable experience and error. Inasmuch as "new hands" will take care of the wounded in future wars, it is important that the principles of débridement be taught to civilian surgeons. An appeal has been made in the regular army of the United States for careful instruction to all medical officers in "traumatic surgery" (39).

Judgment is the prime requisite for good results. From his experiences in the Spanish Republican Army, A. Tudor Hart emphasizes that the success or failure of any débridement depends on the persistence in the wound of non-viable tissue or gross foreign matter. The ideal for which one must strive is to make a clean wound out of a dirty one. This is accomplished by the excision in mass of all torn. crushed, discolored, and non-contractile muscle, along with loose bodies and bone and requires a sound knowledge of anatomy. In general, primary closure of these wounds is undertaken only if the skin edges come together without tension and when the wound is less than 12 hours old. The indiscriminate use of tourniquets caused much damage in the last world war (68). Infection, massive gangrene, pain, tissue ischemia, and gas gangrene have all been attributed to the careless use of the tourniquet.

Ogilvie, in an excellent discussion on the treatment of wounds, carefully divides the progress of wound infection into two stages: contamination and infection. In the first stage (contamination), bacteria which have been carried in by the agent inflicting the wound lie on its surface, in bits of dirt, clothing or metal fragments, or in the blood clot. This is the stage in which the bacteria can be removed by thorough mechanical cleansing. In the second stage (infection), the bacteria profiting by the supply of culture medium available to them in the dead matter, blood-clot, lymph and damaged muscle, have multiplied and started to invade the host. For practical purposes the stage of contamination may be looked upon as lasting 12 hours before it passes into that of infection. When the organisms are few, the available culture medium scanty, and the surrounding tissues healthy, the state of the patient's skin and clothes and the appearance of the wound will aid in an estimation of the probable degree of infection. Doubt as to the condition of the wound should incline one to pessimism rather than to mistaken optimism.

Levaditi (27), working with the French Army has made bacteriological studies on war wounds, both in 1914–1918 and in the current war. Of 317 cultures just taken, 32 per cent contained 3 species of organisms, 19 per cent contained 1 species, 19 per cent contained 4 spe-

cies, 23 per cent contained 5 or 6 species, and 7 per cent were sterile. The species most generally observed were: staphlococci, 85 per cent; Friedlaender's bacillus; Clostridium welchii; streptococci; colon group; Bacillus pyocyaneus. He states that strong doses of -p-aminophenyl sulfamides applied *in situ* in powder form or in glycerine have had a remarkable prophylactic effect.

Col. Leon Colebrook (28) estimates that streptococci are responsible for at least 70 per cent of all deaths due to infection of wounds. Of 49 positive blood cultures, 44 were hemolytic streptococci. Fifteen per cent of all wounds culture streptococci within 12 hours and in a few days the percentage is much larger—up to 90 per cent. It seems, therefore, that if sulfanilamide were present in the circulating blood at the time the organism reaches the tissue an infection might be prevented. Since a single prophylactic dose is excreted in 10 to 20 hours, the following dosage is advocated by Fuller and James:

1st dose 1.5 grams dissolved in 100 cubic centimeters of 1 per cent hot citric acid solution or hot lemon juice
2nd dose 0.5 gram without dissolving to delay absorption, 2 hours later.
Subsequent doses 0.5 gram at 4 hour intervals for 4 days.
Total dose 13.5 grams in 4 days.

Colebrook also states that sulfapyridine is more effective in gas gangrene than sulfanilamide. The danger of granulocytopenia in the case of either drug is mentioned.

Delayed closure (11, 14, 40, 41, 43, 68) is recommended in wounds that are more than 12 hours old and, in the presence of obvious infection, they are thoroughly opened and irrigated with Dakin's solution. An electrosurgical apparatus weighing only 19 pounds has been designed for use in the recent Spanish War (8). Its use is enthusiastically advocated because the current destroys bacteria, bleeding is minimal, and postoperative shock is minimal presumably due to severed nerve ends and reduction in loss of blood. It is also suggested that roentgen-ray units be incorporated in the equipment of mobile surgical and evacuation hospitals for therapeutic use in all potentially dirty wounds (38). However, no evidence is given that the prophylactic use of roentgen-ray is beneficial as an adjunct to thorough débridement. Recent communications from Paris (27) reveal that the sulfanilamide derivatives are being applied to wounds *in situ* as a prophylactic measure. A. Tudor Hart, a major in the Republican Army in the recent Spanish War, states that sulfanilamide was used in the treatment of septic wounds in Barcelona but the record of the results was lost when the city was captured with disorganization of the entire medical service (35).

Compound fractures. Joseph Trueta, from his experience in the Spanish Republican Army has reported upon a total of 1,073 compound fractures treated by the "closed" method. This uniform method, consisting of immediate débridement after reduction of the fracture and immobilization in a plaster cast, in his experience, has proved of special value in wartime. This is particularly evident in that there were only 6 deaths in this series and only 1 case of gas gangrene. Some 20,000 cases were treated by this method, but detailed statistics are not available. This method of treatment which was advocated by H. Winnett Orr was employed over 30 months of continual treatment of war casualties, including the immediate surgical treatment of casualties in over 300 air raids. Although there was only one case of gas gangrene in the series of Trueta, one whole hospital in Madrid was utilized for the treatment of gas gangrene in General Franco's Army. Alvarez (65) in Madrid reports 61 cases coming under his care alone, and this complication was common enough that frequent appeals for large amounts of gas gangrene serum were made. It is significant that both armies were fighting on the same type of soil. A. D. Wall, in discussing the care of the wounded in the war in China in 1937, mentions that the closed treatment of compound fractures was utilized universally with excellent results. D'Harcourt, Folch and Oriol have published results from the application of this technique in the Republican Army. During the latter period of the war they were responsible for the treatment of 7,500 fractures and cared for 17,000 others treated in other centers. Although the total number of casualties is not available, in the Battle of the Ebro, for instance, a surgical unit dealt with 120

casualties, and in only 5 cases were amputations necessary. At the Vallcarca Hospital, Barcelona, of 5,000 wounded treated by them in 1 year only 26 secondary amputations were performed, and very few serious complications were encountered. In the course of the year the number of deaths among the 5,000 wounded was 37; 15 of these were due to gas gangrene, 17 were due to septicemia, and 5 to secondary hemorrhage.

It is emphasized that the essential procedure in the "closed" treatment of compound fractures is one of débridement, and Trueta feels that the factor of vitality of tissues as the decisive element in infections has not been given its due importance. The greatest danger of infection lies in devitalized muscle. The other great factor, as pointed out by Ogilvie, is the length of time elapsing until treatment is instituted. Shock has been observed only in those cases in which there is delay in treatment which Trueta attributes in each instance to the absorption of devitalized muscle. The important principles in this treatment consists of (1) extensive and accurate débridement with removal of all foreign matter; (2) reduction of the fracture—internal fixation is seldom used; (3) after reduction, immobilization is accomplished with plaster which is virtually skin tight. The only padding used is for the os calcis, malleoli, and other bony prominences. The use of windows in the cast is vituperatively condemned as an avenue for the introduction of infection. Brewers' yeast in the wound is recommended as a method of reducing the odorous qualities which are always present in a high degree.

The only failures of this method are attributed by the author to faulty technique which is usually inadequate débridement. Only 8 cases of lymphangitis or cellulitis were encountered in Trueta's series of 1,073. The final results as given in the *Lancet* (64), from the standpoint of function, are: good, 90.9 per cent; bad, 8.6 per cent; deaths, 0.5 per cent. To those who were engaged in the care of the wounded in the last war, these figures are impressive.

However, there are several articles in the French literature by those who received many of the Spanish refugees after the "closed" method of treatment had been carried out. It is evident from their experiences that there may be pitfalls in this method (1, 56, 60).

Ricard, Francillon, Deplante, and Mathevon concluded from their experience in treating "many" of these refugees that many of the fractures were badly or not at all reduced, projectiles were often still present in the wound, and the infection present precluded the possibility of subsequent surgical treatment for months. Some of the wounds were apparently treated with superficial cleansing and immobilization alone. They felt, therefore, that rigorous immobilization gave advantage only when proper treatment to the fracture had been carried out. They were likewise surprised to see the method applied to all cases, especially joints. Although, in general, the refugees were in good condition physically, the condition of the extremity from the standpoint of function was extremely poor. This paper which was given at Lyon was then discussed by Peycelon who stated that he had occasion to treat 60 refugees, some wounds over 2 months old. He called attention to the fact that the Spanish referred to this treatment as the "American method." Fistulas draining pus sometimes at a good distance from the original wound were observed in many instances. Others had extensive pressure areas in the axilla, on the palmar surface of the wrist with gangrene of the flexor tendons, ulcers over the popliteal space and over the malleoli. Five amputations of the thigh or arm were carried out because of the extensive infections. He therefore removed all plaster from these patients with "remarkable improvement."

Mallet and Guy treated 83 Spanish casualties. Of this group 29 were immobilized in extensive plaster, 25 were fractures, and 4 extensive wounds of the soft tissues. Eleven had high temperatures. One amputation of the thigh was necessary because of the presence of infection.

The wounds encountered by Creyssel all seemed to be stagnant and the pressure areas sometimes assumed graver proportions than the original wounds. The plaster was badly applied and several of the patients had oscillating temperatures and chills. One thigh amputa-

tion had to be done. All of the complications were observed, however, in those patients in whom the initial removal of the foreign body had not been done. He concluded: "The initial surgical act is indispensable and the cast should always be fenestrated."

Gabrielle treated 300 Spanish refugees in the Lyon hospital. One hundred were discharged immediately because of minor wounds. About *one-third* were found to have been treated correctly with good results. Sixty of these patients had not been operated upon at all, 40 were treated with simple dressings, and 20 were immobilized in circular plaster. The plaster which had been applied in the 10 cases of soft tissue injuries alone appeared useless, the joints were unnecessarily stiffened and the projectiles remained. He concludes: "All casualties should be operated upon as soon as possible. It is useless to immobilize for transportation common wounds of soft tissue. Fractures should be correctly immobilized. In the French Army all fractures will be treated with good immobilization after operative treatment. The casts will be fenestrated for *surveillance* rather than for frequent dressings."

In the course of a detail early in 1939, Arnaud, Perves, Caire, and Morvon took care of more than 2,000 wounded militiamen of the Spanish War on the hospital ships Marechal-Lyautey and Asni (1). They observed about 600 cases of wounds of the extremities treated without exception by large circular closed plasters which had been applied over the fresh wounds. These wounded were received at the time of the complete debacle of the Republican Army. An interesting account follows:

"The wounded, forced from the surgical ambulances by the thrust of the victorious armies, had fled, and as best they could by their own means had crossed mountains covered with snow. Provided with thick plaster casts, reinforced and supported by splints with stirrup bandages to ease their walking, these wounded having had no attention for several days, badly nourished and sleeping in the open air, were collected and hospitalized on hospital ships. It was only the *survivors* of such exodus that we had under treatment. Most of the wounded had been struck by shell fragments, generally of small volume as were at least those pieces which were still in place, and needed operation. These treatments seemed to us to have been made sometimes by improvised surgeons. On opening the plasters, we noticed without difficulty not only that many of the wounds had been incompletely operated upon, since they still contained shell fragments, but besides that the segments of the limbs were not always in the position allowing the best recuperation, especially in cases affecting the forearm and the wrist. The plaster casings gave off a fetid odor and in some cases we noted that a flow of pus appeared at one of the extremities of the plaster. Very few complained of having suffered in the course of their exodus or of suffering from lesions which their plaster cast concealed."

Extensive infections with fistulas were observed in certain instances. In 1 case, a compound fracture of the forearm was complicated by fistulas in the skin of the hand and forearm. Another fistulous tract ran from the base of the arm to the posterior part of the thorax. They noted almost without exception that these complications developed in unusual clinical silence for they were not accompanied by changes in temperature. About half of those who had a correct surgical operation at the time of injury had healed in the normal time and in an acceptable manner, although the neighboring soft tissues had not healed. The other half presented frankly mediocre results. As for the fractures of the femur, *all had bad results*. Secondary displacement had occurred under the plaster and angulation and overriding in the presence of infection constituted a complex orthopedic problem. The worst results were in joint wounds. They demanded amputation. The functional results were very mediocre and it appeared evident that the surgeon had shown little interest whatever in the possibility of functional recovery. Ankylosis in very bad positions, stiffness in many joints, vasomotor and cutaneous and bone changes, fingers held rigidly straight, were current observations as soon as the plaster was removed. Arnaud and his associates conclude that this method of treatment should be reserved only under unusual war conditions, namely, a great mass of wounded, or when there is difficulty in evacuation, reduced trained personnel, lack of dressings, etc.

"We consider it well established that the removal of the plasters should be as soon as possible after evacuation. Difficulty of inspection of the wounds under plaster is great and we cannot forget the separation of fractures, the arthritis that we have discovered after the removal of plasters, which no revealing symptom allowed us to suspect."

It is obvious that the unusual conditions occurring at the time of the debacle of the Republican Army have precluded a satisfactory analysis of the end-results in these patients. A. Tudor Hart stresses the principle of continuity of treatment and of surgical responsibility in all cases. This can be achieved only if the patient is kept at one place. It is also recommended that there be standardization of stretchers so that a wounded person may not be moved from his original stretcher until the operating room is reached.

When these principles were observed, it was apparent that excellent results were obtained, however. Dr. Rudolph Matas (14) personally visited the Catalonian war zone where over 5,000 wounded were under treatment. In one base hospital at Banolas, one ward devoted exclusively to fractured femurs had 75 or more patients under treatment. He states that there was apparent universal agreement on *débridement*, reduction under mechanical traction and anesthesia, controlled by roentgenograms, with packing of the wound, free drainage into a completely closed and immobilizing plaster encasement, which was allowed to remain *in situ* without change, until the healing of the wound had advanced sufficiently to become protected by granulation against secondary infection.

Matas relates:

"I had an opportunity to see several plaster encasements removed from arms and thighs after they had been *in situ* for from 15 to 21 days. The stench of the soiled encasement was nauseating. A magma or mush of decomposing pus, wound secretions, including sweat and other matter, covered the surface of the wound under the plaster bandage. But after wiping this off with warm water and soap, and when the packs were removed, I was surprised to see the excellent, healthy, pink, well-granulated appearance of the wounds, coupled with a very satisfactory condition of the patients—no fever, no pain, good appetite, etc. This was indeed a revelation which I had not anticipated. Suffice it to say that when fresh wounds are relieved of all dead or devitalized tissues, they are, when put to complete rest, quite able to take care of themselves without the aid of antiseptics, which hinder the normal reproduction of the tissue cells and weaken their defenses. At any rate, it would seem that a symbiotic existence is possible between the normal tissue cells and the saprophytic bacteria and other pathogenic organisms that gather under cover of a plaster encasement. In fact, if there was one essential for the successful treatment of fractures, it was plaster of Paris. By the close of the war plaster had risen to the level of an apotheosis in surgical esteem."

A statistical summary furnished by Jimeno (14) of Barcelona showed that 500 fractures of the femur had been treated by the "closed" method with a mortality of 16, or 3.2 per cent. There were 5 amputations—4 necessitated by infection and 1 by gas gangrene, which had appeared before patients were admitted to the hospital.

A final opinion on this method of treating war wounded should probably be reserved. The results are equivocal inasmuch as on one hand, one reads:

. . . . "plaster had risen to the level of an apotheosis in surgical esteem."
. . . . "a revelation which I had not anticipated."
. . . . "the plaster maintains a constant beneficial effect on the wound."

And on the other hand one reads:

. . . . "pressure areas sometimes assumed graver proportions than the original wounds."
. . . . "fistulas draining pus sometimes at a good distance from the wound."
. . . . "a flow of pus appeared at one of the extremities of the plaster."
. . . . "as for fractures of the femur all had bad results."
. . . . "functional results were very mediocre."

Cranial wounds. The incidence of cranial wounds in the French Army has dropped from 15 to 3 per cent since the introduction and use of a steel helmet (40). An excessive mortality rate in this group is attributed to primary hemorrhage so that only about 25 per cent reach the field hospital. Another great factor is the delay in transportation which necessarily increases the danger of intracranial infection. All treatment is concerned with prevention of infection and reduction of eventual cerebral phenomena. Sulfanilamide is employed freely and the necessity of skilled attention is stressed in this group of patients by the Germans (9). The German Army strives to treat all wounded within 8 hours, often flying the wounded soldier to the interior where trained personnel is available (62). The principles of traumatic neurosurgery during peace time are applicable in times of war. The greatest problem in times of war is the provision of adequate skilled personnel.

This need for specialized personnel is further evident in recent communications from London (30, 34). The London correspondent of the *Journal of The American Medical Association* writes that one of the latest advances in the British Army is a mobile unit for cranial surgery at the front. They have constructed a motor lorry which carries a separate engine and dynamo for cautery, lights, suction, and a 12 volt accumulator for an electromagnet. This unit carries two complete sets of neurosurgical instruments, two folding operating tables with head rests, two folding instrument tables, and anesthesia apparatus. There are also oil stoves for sterilizing. The Personnel includes: 1 neurosurgeon, 1 neurologist, an anesthetist, 2 surgical assistants, and 2 operating-room nurses. This unit operates at casualty clearing stations and carries enough supplies for several hundred neurosurgical operations and may remain in the forward areas for weeks at a time. Units of this type answer the needs for medical care which may keep pace with the rapidly moving front.

The prevention of hemorrhage in extensive wounds of the face and oral cavity is accomplished by massive packing of the pharyngeal cavity followed by tracheotomy. The Japanese have employed this procedure on a large scale and are said to have saved many lives who would otherwise have died from hemorrhage at the field (17, 68).

Thoracic wounds. Crafoord has estimated that 30 to 40 percent of all fatalities are due to chest injuries. Transportation of this group is especially dangerous and most of them die at the front from hemorrhage. The emergency nature of this type of wound should probably give it preference over all others (15, 33, 55). Ranson relates his experiences with gunshot wounds of the chest in the Sino-Japanese War during 1937. About 1 wound in every 12 is in the chest and the number of men who die on the field of chest wounds is from one-half to one-third of the total number killed. The English in the war of the Crimea lost 79.2 per cent of all men who were wounded in the chest and who arrived at the hospitals for treatment. The figures then show a definite progress and trend through the American Civil War, the Franco-Prussian War, the Spanish-American War, the Boer War, the World War, and the Sino-Japanese War of 1937. In the last war, the wounded who died from chest wounds after being treated in the hospital amounted to only 14.8 per cent.

Pneumothorax is a most important consideration in the treatment of chest wounds. Mediastinal flutter is of great importance because of its effect upon the great veins which carry blood to the heart. The systolic output is dependent upon the diastolic inflow, and the mediastinal flutter causes periodic obstruction to both the superior and inferior venæ cavæ. The symptoms of open pneumothorax are due, therefore, to a circulatory disturbance rather than to the respiratory disturbance *per se*. Other important points are the rapid loss of heat from the chest and the great tendency toward infection. Tension pneumothorax produces even more marked symptoms of distress than the open variety because the pressure in the pleural cavity of both sides approaches a positive value. A tension pneumothorax, unless relieved, invariably leads to a fatal outcome.

The carefully managed differential pressure treatment as carried out by Sauerbruch in the World War resulted in only an 18 per cent mortality in 300 cases. The use of heavy dressings which restrict thoracic breathing is warned against. The treatment consists of thorough débridement, resection of ribs with a good opening into the pleural cavity. The pleural cavity is carefully cleansed and all vessels which are bleeding are ligated, foreign bodies are extracted, and débridement of injuries to the lung is carried out with primary suture. Lobectomy or pneumonectomy may be indicated. Exact suture of tracheal or extrapulmonary bronchial injuries is carried out and the esophagus is carefully examined for injuries. Primary suture of the defects in the chest wall follows closure of the parietal pleura after the lung is expanded. Crafoord classifies thoracic wounds as (1) wide open pneumothorax, (2) outer or inner bleeding, (3) tension pneumothorax, (4) mediastinal emphysema, and (5) injuries to the esophagus.

Abdominal wounds. A war of motion causes a greater incidence of abdominal wounds. In

1917–1918, in the Finnish War, the incidence was only 2.97 per cent; in the World War 4.6 per cent (63). During the World War surgical operation was regularly employed. Prognosis during the first 6 to 8 hours was excellent and later than 36 hours the mortality rate approached 100 per cent. Matas (61) in discussing penetrating wounds of the abdomen quotes Baron who has estimated that 10 per cent of the 1,185,000 soldiers who were killed outright on the battle-field in the World War died from the shock and hemorrhage of penetrating abdominal wounds. Therefore, 118,500 abdominal deaths on the battle-field occurred before any surgical assistance could possibly reach the striken men. Death follows gunshot and other wounds of the abdomen as a result of hemorrhage, shock, and infection. Although shock and hemorrhage require prompt institution of measures at the front, it is possible that infection following abdominal wounds can be greatly minimized. Storck outlines investigations that are now being done to determine the possibility of replacing the pathogenic bacteria with non-pathogenic ones in the intestinal tract of soldiers before going into battle. By feeding cultures of Bacillus acidophilus for 3 or 4 days it is possible to change the bacterial flora of the intestinal tract, and it is hoped by this means that infection following war abdominal injuries can be greatly reduced.

The principles of peace-time abdominal surgery are perfectly valid in times of war. Cases should be carefully selected with localization of foreign bodies by x-ray along with institution of pre-operative measures to combat shock. Little is accomplished in any event by laparotomy after 12 hours with the possible exception of prolonged hemorrhage from upper abdominal wounds. Pre-operative measures include heat, morphine, 100 per cent oxygen for air-hunger, blood in adequate amounts and 3000 units of antitoxin. Blood has become generally available through improvements in preservation, refrigeration and transportation (10, 20, 22–26, 51, 58). Spinal anesthesia is used cautiously. Ether is used frequently because of its general availability.

Matas provides a bibliography of recent Spanish War literature on abdominal wounds (2–6, 12, 16, 19, 59). He summarized them as follows:

"The general conclusions arrived at by Baron (2, 3) serve as a sample of the general surgical experience of the Spanish Civil War. Of 500 well recorded abdominal wounds, 239, or 47 per cent, were regarded as inoperable and were not celiotomized because (a) they were brought from the field in a hopeless, dying condition—in this group there were 192 of the wounded of whom 97 per cent died; (b) in 47 of the non-operated upon group, no celiotomies were performed because the visceral lesions were limited to the liver and it was thought that they had a better chance of survival without operation. The mortality in this group was 19 per cent, thereby confirming the good judgment of the surgeons in not operating. (2) Celiotomies were performed for penetrating gunshot wounds in 261 patients (52 per cent of the 500 admissions), on an average of 7.5 hours after the injury had been inflicted. In 22 of these celiotomized patients, the lesions involved, almost exclusively, the parenchymatous organs, especially the liver; and, in this group, there were 47 recoveries, or a mortality of 54 per cent. (3) Two hundred forty were celiotomized for lesions of the gastro-intestinal tract, alone or conjointly with other visceral wounds. In this group only 25 per cent recovered and 75 per cent died. (4) Not included in these 500 cases were 22 exploratory celiotomies for penetrating and non-penetrating, uncomplicated visceral injuries; the mortality in this group was 55 per cent. In addition, there were 16 patients with possibly penetrating but seemingly, uncomplicated wounds. In this group, the mortality was only 6 per cent. (5) The great increase in artillery warfare, machine guns, explosive shells, shrapnel, hand grenades, aerial bombs, trench mortars, etc., has increased the mortality of the abdominal wounds by their multiplicity and wider range of destructive action and complications. (6) The number of fatally wounded who survived long enough from the shock and hemorrhage on the battle-field to reach the casualty stations in a moribund and hopeless condition is increasing (35 to 47 per cent). This is particularly characteristic of trench warfare, when the fatally wounded patients die on the field if delayed in transportation, but survive just long enough to expire in the field hospitals when the distance is short and the stretcher bearers are promptly on the spot. (7) Despite the best care and skill, the mortality of exploratory celiotomies is still high, 37 per cent. (8) It would seem that, despite the free and abundant resort to transfusion with whole or preserved blood, and despite favorable conditions for operation, the mortality in perforating wounds of the gastro-intestinal tract still remains high, 75 per cent. (9) The mortality of gunshot wounds of the abdomen involving the gastro-intestinal tract shows relatively little improvement over

the mortality of the same wounds recorded in the experience of the allied French, British and American surgeons or of German operators at the close of the World War, which was largely a stabilized trench war with surgical dugouts close by. (10) Undoubtedly, exposure in freezing temperatures, delay in transportation, starvation, hasty mobilization of the surgical staff, and patients in mobile wars exercise a very decided influence upon the prognosis; all of which was well exemplified in the freezing winter temperatures at Teruel, the Ebro, Segre, and Pyrenean slopes."

Transportation. The ultimate outcome of a wounded soldier depends largely on the time interval which elapses before effective treatment is instituted. Meningitis, peritonitis, and pneumonia are sequels of delay in treatment of cranial, abdominal, and thoracic wounds, which may increase mortality rates tenfold. The ambulance plane coping with problems accompanying increased mobility of the front has made it possible to provide for the wounded the highly developed surgical facilities of the home hospitals. W. Toennis of the German Air Force relates experiences in the Polish campaign. Transportation of 2,500 wounded from Poland to Germany was accomplished by air-transport without undue difficulty. Those with marked secondary anemia were susceptible to "airsickness" which was best relieved by the administration of oxygen. The breathing capacity which is reduced in gunshot wounds of the chest with hemothorax, and in abdominal wounds with elevation of the diaphragm, demands special precautions in transportation. Respiratory difficulty was observed in these patients at 1,300 meters and was relieved promptly by the administration of oxygen. Of 2,500 wounded and sick, transported by plane, only 4 died during the flight or immediately upon landing. Three of the cases mentioned had peritonitis. It was noted that all deaths in flight occurred in planes *not equipped with oxygen.* In a comparison of air transport with land, it is beyond doubt that the former method is less painful, first because of the short duration and second because few jolts are sustained.

A soldier with prolapse of the small intestine, the result of an abdominal shot wound received while in the vicinity of Warsaw, reached the operating table in the clinic at the University of Breslau 2½ hours after he was wounded, the actual time of flight being 90 minutes. Thanks to this record speed the wounded man recovered without complications. The same applied to wounds of the jaw and brain, for the treatment of which, in the field there were neither facilities nor personnel at hand. The majority of patients with head injuries operated upon at the front where no knowledge existed as to the extent of comminuted fractures were not lucky enough to be transported promptly into the indicated section of the home hospitals, and died of cerebral abscesses. By contrast, the patients who were not operated upon and could be observed in the airbase hospital of Berlin, after final treatment, showed no infection. Among the 10 patients taken to the hospital by plane, there were 3 with infection caused by hemolytic streptococci. All such patients transported by air may look forward to recovery. Quick and careful air transportation brought 39 patients with wounds in a short time to a place where they could receive extensive treatment, and where they had absolute quiet. Only 2 of the patients died weeks later from empyema.

"When comparing these results with those of the World War, we who served there and are serving now, have no doubt of the progress made when we can say that of 375 joint-shot fractures treated, but 2 died," (62).

Prevention of war wounds. The value of physical prophylaxis of wounds is apparent from the fact that cranial wounds have been reduced from an incidence of 15 to 3 per cent since the introduction of the steel helmet. It is significant that the great majority of wounds are caused by small missiles of low velocity. Although the armor necessary to protect against high velocity bullets may weigh as much as 20 pounds, compressed fiber or bakelite panels (with the same tensile strength as aluminum and one-half the weight) will suffice for protection against shrapnel and trench-mortar splinters. It is logically assumed that many chest and abdominal wounds, which in the past have been caused by low velocity missiles, may be prevented by the use of some form of light weight body armor.

Sauerbruch found 37 per cent of those dead on the battle-field had extensive chest wounds while at the casualty clearing station the percentage was only 3 (29). Thus in the trenches the vast majority of chest wounds prove fatal from hemorrhage. The recognition by the Germans of the value of preventing wounds in this manner has led to unsuccessful attempts by the Hitler régime to induce an American inventor of armor to equip the German armies (32). However, a war correspondent now reports that the Germans are regularly employing some type of body armor.

Sir Richard Cruise (31), ophthalmologist, has devised a 22 gauge retractible duralumin visor as an accessory to the helmet already in use. He estimates that from 50 to 70 per cent of the blindness which in the last war was caused by small missiles may be prevented in this manner.

Sir Harold Gillies has suggested a gauntlet to protect the back of the hand (32). Mr. Kenneth Walker advocates a light armor for the chest which may also be used as an entrenching instrument with a supplied handle. Interest in the subject of armor in England was highly apparent at a recent meeting of the Royal Society of Medicine where a discussion took place on "the physical prophylaxis of wounds." The following resolutions were unanimously adopted:

"That this representative meeting of the Royal Society of Medicine, after full discussion of the question, is emphatically of the opinion that the physical protection of the members of the fighting forces can and should be improved by a closer collaboration between the medical profession and the appropriate technical experts of the Admiralty, War Office, and Air Ministry.

"That this meeting of the Royal Society of Medicine resolves that the Council be asked to consider the formation of a special committee to this end. As the matter is one of extreme urgency and importance, it is hoped that the president may use his emergency powers and approach the government with the offer of the society's co-operation at the earliest possible date."

SUMMARY AND CONCLUSIONS

The incomplete reports of surgeons caring for the wounded in the present wars indicate more than ever the importance of a sound knowledge of the fundamentals of surgery. Careful débridement skillfully carried out is still the one most important treatment for wounds. Without it no supplementary form of treatment will succeed. Chemotherapy may become important but there is need for more investigation before its utility becomes firmly established. The value of physical prophylaxis of wounds should be vigorously investigated especially as the majority of wounds are caused by the predominant low velocity missile. The value of mobile operating units coping with the increased need for skilled personnel at the front, is recognized. The ambulance plane has already proved of inestimable value. Rapidity in the collection and transportation of wounded reduces the incidence of peritonitis, meningitis, and septicemia. Although conditions may be far from ideal, the principles of peace time surgery continue to be perfectly valid in times of war.

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RATIONALE AND USE OF OXYGEN IN THE POSTOPERATIVE TREATMENT OF HYPERTHYROIDISM

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OXYGEN is a valuable adjunct in the immediate postoperative treatment of patients with toxic goiter. A few reports of its use are found in the literature. Haines and Boothby report its value in 91 patients having severe reactions and cyanosis after thyroidectomy. Schmidt has employed oxygen therapy immediately after thyroidectomy and other surgical procedures with beneficial results. Maddock also comments upon the efficacy of oxygen in the treatment of patients following thyroidectomy. The use of oxygen therapy, however, is not as extensive as it should be, chiefly because of lack of understanding of its rôle in maintaining homeostasis and lack of understanding of the increased oxygen requirements of the hyperthyroid patient.

It should be kept in mind that anoxemia is present long before cyanosis becomes visible. This is most important in the toxic hyperthyroid patient whose oxygen requirements are greater than those of a normal patient and in whom cyanosis is of grave significance. In order to have cyanosis at least 5 gram per cent of reduced hemoglobin must be present. Of practical general significance is the fact that in severe anemia where the blood hemoglobin approaches 5 gram per cent, cyanosis does not develop until the patient is almost moribund; below 5 gram per cent cyanosis cannot occur.

The literature contains a report which indicates that arterial blood oxygen saturation may be decreased below normal in patients with hyperthyroidism. Litarczek reports decreased arterial blood oxygen saturation in 2 of 3 patients with elevated basal metabolic rates (plus 52 to plus 56). We have also determined the femoral artery blood oxygen saturation in 12 hyperthyroid patients before and about 1 hour after thyroidectomy. The samples of femoral artery blood were obtained anaerobically and assayed for oxygen saturation according to the method of Van Slyke and Neill. A record of the blood pressure, pulse, and respiration was also made. Table I shows that the normal oxygen saturation (average 92 per cent) was significantly depressed 2 to 7 per cent in 6 of the 12 patients under basal conditions before the operation. Depression of oxygen saturation was seen most frequently in toxic patients with high metabolic rates. Samples of blood were taken again about 1 hour after the operation. The operations were done under a basal anesthetic of avertin (70 to 90 milligrams per kilogram body weight) supplemented with ethylene and oxygen. The combination of avertin, ethylene and oxygen caused less depression of arterial blood oxygen saturation than barbiturates, paraldehyde, and nitrous oxide anesthesia reported elsewhere by us (9). However, in spite of this, further depression of arterial blood oxygen saturation was observed following operation in 10 of the 11 patients. In Case 8 the oxygen saturation was depressed to 78.1 per cent. No significant fall in blood pressure was observed in any of these cases. Most of the patients developed a slightly elevated blood pressure, pulse, and respiratory rate after the operation. These studies are significant in so far as they revealed that some of the hyperthyroid patients had a mild undersaturation of blood oxygen prior to operation and that this was worse after the anesthetic and operation. This degree of anoxemia is deleterious in view of the fact that there is an increased consumption and need for oxygen in the hyperthyroid patient. This has been shown experimentally in animals and also in our patients. By means of the Warburg gasometric apparatus, Reinwein has found that the addition of thyroxin to the substrate increased the consumption of oxygen by liver

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TABLE I.—FEMORAL ARTERY BLOOD OXYGEN SATURATION IN HYPERTHYROID PATIENTS

Patient	B.M.R.	Pre-operative				1 Hr. Postoperative†			
		Oxygen saturation femoral artery blood per cent*	Blood pressure	Pulse	Respiration	Oxygen saturation femoral artery blood per cent	Blood pressure	Pulse	Respiration
1	+21	84.0	130/80	96	20				
2	+22	91.7	136/86	100	20	90.7	140/95	128	20
3	+29	90.5	140/80	120	20	80.3	140/82	90	24
4	+29	88.6	136/80	100	20	88.3	140/80	110	22
5	+36	90.5	140/86	96	18	93.1	150/90	100	26
6	+36	90.5	130/84	96	20	89.7	120/82	150	24
7	+44	90.9	145/75	104	22	88.7	170/40	104	26
8	+48	88.8	150/90	100	20	78.1	160/70	80	22
9	+57	86.5	220/110	100	20	84.5	224/120	100	32
10	+63	89.6	136/70	128	20	85.3	150/100	150	32
11	+68	92.4	180/80	118	22	85.5	180/90	132	32
12	+68	88.9	210/70	110	20	87.0	210/130	120	32

†Anesthetic: Avertin (70 to 90 mgm. 1 kgm.), ethylene and oxygen.
*Average femoral artery blood oxygen saturation of normal unanesthetized patients is 92 per cent.

cells of the rat. Increased oxygen consumption following administration of thyroid extract to intact rabbits is reported by Saito. Spence also found an increase in the basal oxygen consumption in goitrous rats.

We have studied the effect of the basal metabolic rate upon the oxygen consumption and vital processes in our patients. Fifty patients were divided into 5 groups according to their basal metabolic rate. The volume of oxygen utilized per minute was determined from the gasometric analysis of the air expired by each patient during a 10 minute period. Marked differences in the oxygen consumption and the vital processes were observed under basal conditions in these groups. The results were charted in Table II and plotted in Figure I. The average figures for the pulse and respiratory rates shown were obtained under basal conditions and after bed rest so that they are lower than those frequently observed in hyperthyroid patients not confined to bed. It is seen that the hypothyroid patients had a lower body temperature (average 97.9 degrees F.), a slower pulse (average 70), slower respiration (average 15) and absorbed less oxygen per minute (average 157 cubic centimeters) than the normal patients (average temperature, 98.1 degrees F.; pulse, 78; respiration, 17; oxygen absorbed was 215 cubic centimeters per minute). In the patients with markedly increased basal metabolic rates (+63 to +94) these vital processes were markedly increased (average temperature, 98.6 degrees F.; pulse, 111; respiration, 23; and 337 cubic centimeters of oxygen were utilized per minute). Hypothyroid patients tended to be overweight and sluggish while hyperthyroid patients tended to be underweight, hyperactive, nervous, and perspired easily. It is seen that hyperthyroidism results in a marked increase in the oxidative processes. When catabolism exceeds anabolism, there results a burning up of body tissues and loss in body weight. In severe cases weight loss is profound (30 to 40 pounds) and oxygen consumption may be increased as much as 56 per cent above normal.

The cardiovascular reactions in cases of toxic goiter are increased to the detriment of the patient. In an attempt to transport more oxygen and nourishment to the tissues, and carbon dioxide and metabolic waste products away from them, the heart rate increased from an average basal normal rate of 78 to the average basal hyperthyroid rate of 111 beats per minute. The resulting increase in cardiac

TABLE II.—RELATION OF BASAL METABOLIC RATE TO VITAL PROCESSES AND ABSORPTION OF OXYGEN

Patient	Hypothyroid		Normal		Hyperthyroid					
	B.M.R.	c.cm. O_2 per min.	B.M.R.	c.cm. O_2 per min.	B.M.R.	c.cm. O_2 per min.	B.M.R.	c.cm. O_2 per min.	B.M.R.	c.cm. O_2 per min.
1.	−33	141	−1	206	+36	257	+54	286	+71	280
2.	−22	161	±0	232	+37	251	+56	279	+73	425
3.	−23	166	+3	217	+35	239	+52	261	+84	320
4.	−22	137	±0	212	+35	330	+54	382	+64	347
5.	−23	187	±0	192	+39	336	+53	276	+94	336
6.	−25	185	±0	240	+41	305	+55	312	+72	298
7.	−25	184	+1	259	+41	254	+53	297	+63	342
8.	−27	144	±0	196	+40	288	+52	246	+65	353
9.	−20	182	+1	171	+37	286	+52	299	+72	340
10.	−25	159	+3	229	+36	284	+51	317	+68	332
					Average					
c.cm. O_2 Absorbed	−20 to −30	157 c.cm.	−1 to +3	215	+35 to +41	282	+51 to +56	296	+63 to +94	337
T (°F.)		97.9		98.1		98.3		98.5		98.6
P		70		78		84.6		98.6		111.4
R		15		17.2		18.7		20.2		23.4

output greatly decreases the cardiac reserve. The increased pulse rate interferes with the coronary circulation to the myocardium because of the shortened diastole during which phase filling of the coronary vessels occurs. Prolonged anoxemia under increased demand may lead to angina pectoris, coronary occlusions, myocardial asthenia, and decompensation. The hyperexcitability of the nervous system may lead to arrythmia and irregularity. Acute and chronic anoxemia causes enlargement (Van Lier), hypertrophy (Bouchut), and fatty degeneration (Hitzenberger) of the heart.

With an increased basal metabolic rate there occurred an increase in the respiratory rate. The tachypnea is a physiological attempt to increase the absorption of oxygen and to facilitate aeration of the quickened circulation. Dyspnea is a prominent symptom in advanced cases. The irritable patient with a toxic goiter is conscious of this difficulty in breathing and feels that he must voluntarily assist the normal movements. This leads to increased restlessness and nervousness. The dyspnea may be (1) reflex from worry, restlessness, sleeplessness; (2) cardiac insufficiency; and (3) decreased vital capacity. In hyperthyroid patients the vital capacity is decreased below normal (3700 cubic centimeters) due to increased tone together with some inco-ordination of the skeletal muscles and an increased irritability of the vagus nerve endings in the lungs. Asher (1) has demonstrated the effect of the thyroid gland upon sensitivity to anoxia. Rats fed thyroid extract showed signs of air hunger and suffocation in atmospheres the oxygen deficiency of which did not affect normal rats. He also reported (2) that rats whose thyroid glands have been removed did not show any of the phenomena of suffocation exhibited by normal rats in oxygen deficient atmospheres.

Physiological processes are less stable than in the normal patient, and therefore the reactions of the toxic thyroid patient should be closely watched because they are violent and superimpose a further strain upon the already overburdened vital reserves. An increase in the pulse rate may be one of the early signs of increased oxygen demand. Frequently this may become elevated to 130 to 160 beats per minute. The respiratory rate may increase to 40 or 50 respirations per minute, and the body temperature may rise to 104 or 105 degrees F. These reactions are most common following thyroidectomy in the very toxic patient. How-

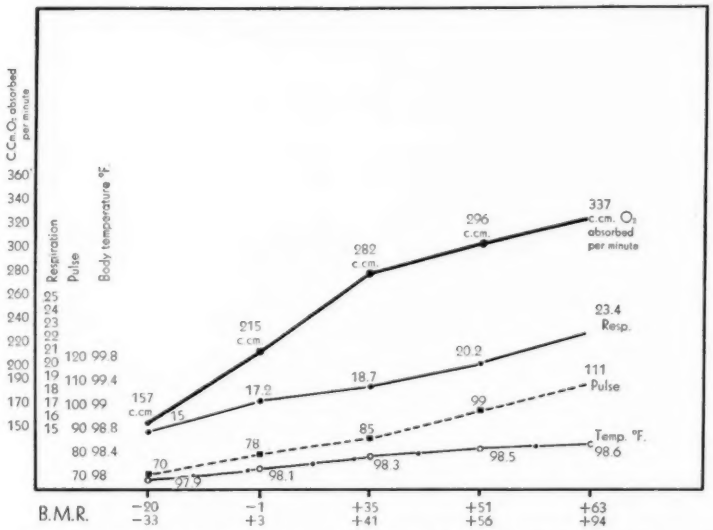

Fig. 1. Relation of the basal metabolic rate to the temperature, pulse, respiration, and the absorption of oxygen in the human. (Average 10 patients each.).

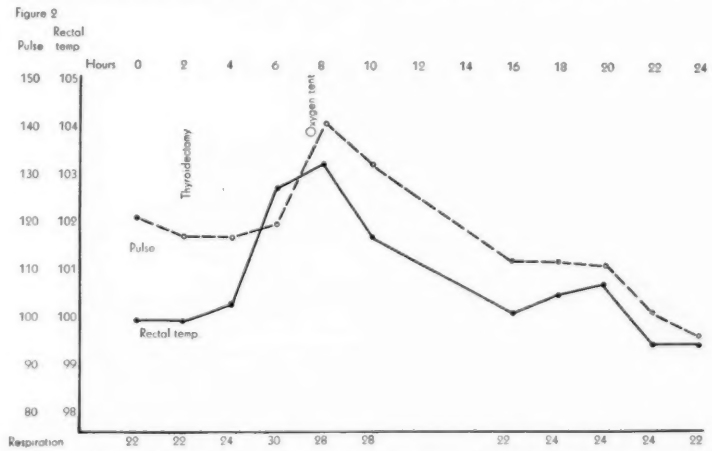

Fig. 2. Prompt reduction in temperature, pulse, and respiration in a postoperative hyperthyroid patient when placed into oxygen tent.

ever, severe reactions and fatal crisis may be precipitated by relatively minor factors.

In a group of 51 pre-operative deaths from thyroid crisis, Bayley reported that the crisis was precipitated by extrathyroid surgery in 6, acute infection in 8, therapeutic and minor diagnostic procedures in 9, insufficient treatment, sleeplessness, and overactivity in 19, while the rest were admitted during the crisis. Because of this risk, McGraw has found that short interval stage operations for severe hyperthyroidism reduced the mortality to 7.5 per cent in the group of 161 patients reported.

Since our more extensive use of the liquid oxygen tent immediately after operation, we have had only 5 thyroid deaths in a series of

202 consecutive operations. This is a mortality of 2.4 per cent. Two of these deaths were due to bronchopneumonia, the 3 others to acute hyperthyroidism. All of these patients were close to 60 years of age and had hypertensive heart disease. In addition, one of them had diabetes and arteriosclerotic kidney disease. Because of the number of varying factors such as better pre-operative preparation and stage operations, it is difficult to evaluate the rôle that oxygen therapy had in this reduced mortality rate. However, we could not help but be impressed with certain features. The cool moist atmosphere in the liquid oxygen tent and the high oxygen concentration exerted a sedative action and decreased restlessness; the high oxygen tension made breathing easier so that the rate decreased and dyspnea was less severe or abolished; it decreased the heart rate and so maintained the cardiac reserve, frequently correcting arrhythmia and decompensation. Early restoration of the elevated post-operative body temperature to normal was frequently seen. A typical reaction is seen in Figure 2. The increased availability of oxygen in the tent atmosphere (average 60 per cent oxygen) gave the toxic patients the subjective sensation of well being and objectively they did not appear as sick as one might have expected them to be.

SUMMARY

1. Six of 12 hyperthyroid patients under basal conditions showed a depression of arterial blood oxygen saturation 2 to 7 per cent below normal. About one hour after thyroidectomy, performed under avertin, ethylene and oxygen anesthesia, 10 of the 11 patients showed a further depression of oxygen saturation. In 1 patient the oxygen saturation was depressed to 78.1 per cent.

2. Under basal conditions progressive hyperthyroidism is associated with an increased consumption of oxygen. A group of hyperthyroid patients consumed 56 per cent more oxygen than a similar group of normal patients.

3. Vital processes, such as body temperature, pulse, and respiratory rates, are increased above normal in patients with toxic goiter. This decreases the systemic and cardiac reserve.

4. An increasing pulse rate is frequently one of the first signs of increased demand and diminishing reserve.

5. Anoxemia is present long before cyanosis becomes visible.

6. Oxygen therapy is indicated in the post-operative treatment of patients with toxic goiter because they showed a postoperative anoxemia and because they utilize more oxygen than the normal patient.

7. Oxygen therapy exerts a sedative effect upon the patient following thyroidectomy. It facilitates aeration in the lungs decreasing the respiratory rate and diminishing or abolishing dyspnea. The heart rate is slowed and prompt reductions in body temperature are seen.

8. Oxygen therapy, better pre-operative preparation, short interval stage operations, have all helped to decrease the mortality to 2.4 per cent in 202 consecutive operations for toxic goiter.

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THE SURGICAL PROBLEM OF CHRONIC GASTRITIS

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THE early diagnosis of gastric carcinoma is the hope of every surgeon. Unfortunately, at surgical exploration, disappointments are all too common, even when the clinical symptoms seem relatively early. Gastroscopy now offers another aid in the early and differential diagnosis of malignancy (15, 18). Although no biopsy is possible by this method, it has stimulated a greater interest in the histopathology of the gastric mucosa, by correlating the gastroscopic picture with the microscopic study of surgical specimens. In the evaluation of this knowledge, however, cases occasionally occur that present great difficulty in the differential diagnosis of carcinoma from the chronic hyperplastic form of gastritis. These unusual cases may perplex not only the roentgenologist, but also the gastroscopist, and at times even the surgeon during exploration of the stomach. Unless the latter is familiar with this pathological condition, he may well be confused as to the proper policy to pursue when suddenly confronted with the situation during operation. We wish to discuss this problem, and to report a few cases in point.

The gastroscopic clinic at this hospital is in the hands of well trained men. It has functioned with increasing success for the past 3 years and has been of great value as a diagnostic aid. We state this advisedly, lest it be considered that the gastroscopic observations reported here were at fault. In addition, we quote similar experiences of men well versed in the method.

Two types of hyperplastic gastritis have been described which, when severe, may simulate tumor formation. Schindler (15) speaks of chronic hypertrophic gastritis as an entity, entirely benign but frequently more intractable to medical treatment than peptic ulcer. There is mucosal proliferation of varying degree, and cellular infiltration of lymphocytes and plasma cells, with superficial ulcerations often occurring. On the other hand, there is a chronic hyperplastic form, usually described as an antral gastritis, characterized by atrophy of the glandular elements of the mucosa, but hyperplasia of the surface and crypt epithelium and connective tissue. This condition is believed to be probably precancerous (7, 10, 11, 17). In either condition, the cellular infiltration may extend to the muscularis mucosæ and the submucosa, and there may be submucosal and muscular hypertrophy. Faber suggests that both types may be different stages of a progressive disease, rather than distinct entities. A severe hyperplastic gastritis may give rise to symptoms that are confusing with those of ulcer, polyposis, carcinoma, and lymphoblastoma. There is nothing characteristic of the gastric acidity, and the stools may or may not show occult blood (15).

The senior author and Pearl (4) were the first to describe a case of hypertrophic gastritis simulating tumor formation, in a paper on polyposis, 1926. Although the history, symptoms, and roentgen findings pointed toward polyposis, at operation the surgeon was confronted with an entirely unexpected and unusual condition, which was difficult to classify at the time. We describe it here in some detail, since it is now known to fit into the category of the cases to be presented:

A woman, aged 30 years, had complained of indigestion, occasional vomiting, diarrhea, and upper abdominal pains for 10 years, growing progressively worse. Physical examination was negative. Laboratory examination revealed a mild secondary anemia, occult blood in the stools, and an achlorhydria. Roentgenological examination disclosed multiple small, finger-like filling defects along the upper two-thirds of the greater curvature, and to a lesser degree along the lesser curvature. A diagnosis was made of diffuse gastric polyposis. At operation, however, only a slight thickening of the stomach wall was felt. Through an anterior gastrotomy incision, no polyps were evident, but a markedly hypertrophied mucosa thrown into enormous folds of various sizes, some 7 to 9 centimeters high. This very thickened mucosa was freely movable upon the submucosa and could be actually withdrawn through the incision. The hypertrophy involved chiefly the proximal two-thirds of the greater curvature and the upper third

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of the lesser curvature, merging gradually into the adjacent normal mucosa. Specimens were obtained at different sites, and the gastrotomy opening was closed after a large portion of prolapsed mucosa was removed. The patient made an uneventful recovery. Pathological examination by Dr. Rusk revealed a distinct thickening of the mucosa, with normal surface epithelium. The surface presented occasional shallow clefts. The glands were very tortuous and lined with normal epithelium. Some of the glands in the deeper portion of the mucosa were dilated into small cysts. A marked edema involved the interstitial tissue of the mucosa, the muscularis mucosæ, and the submucosa. This edema was associated with a marked infiltration of plasma cells, frequent eosinophils, and occasional large undifferentiated mononuclear cells, and extended in moderate degree through the muscularis mucosæ. Frequent focal hemorrhages were scattered throughout the mucosa, with conspicuous dilatation of blood vessels throughout. Lymphoid follicles showed no abnormality. A pathological diagnosis of hypertrophic gastritis was made. After 14 years, intermittent attacks of mild abdominal distress and diarrhea still occur, controlled fairly well by a bland diet and dilute hydrochloric acid.

Schindler (16) recently described several striking cases of proliferative gastritis, in which even at surgical exploration, as well as by roentgen and gastroscopic means, it was difficult to make a definite diagnosis. He included in his group Case 1 of this series, which is here described in full. In treatment, he advises resection only in isolated polypoid gastritis of the antrum, which is probably precancerous. When the diagnosis is uncertain as to hypertrophic gastritis or carcinoma, he favors thorough microscopic examination of a biopsy specimen, with delay of resection until carcinoma is proved, since frozen sections of the gastric wall are unsatisfactory. Otherwise, conservative treatment is recommended because of the hazards of gastrectomy.

Konjetzny (12), on the other hand, believes that resection is indicated in all these doubtful cases, since it not only furnishes the final diagnosis but also effects a cure. He reported 3 cases of tumor-like gastritis, entirely well 5 and 6 years after operation. Floercken has had similar results, and agrees with Konjetzny as to therapy.

Kantor described 2 cases of giant rugæ on the greater curvature of the stomach, in which the roentgenological appearance suggested carcinoma. The presence of hypertrophic gastritis was disclosed at operation. Crohn reported 8 similar cases, in 6 of which operation was performed under the diagnosis of malignancy. In addition, there were 9 cases of antral gastritis of marked degree, in 5 of which resection was done for carcinoma. Gastroscopy was not available in these cases. Eusterman has described several similar cases at the Mayo Clinic.

Both Moutier and Benedict (2, 3) also give testimony as to the gastroscopic difficulties in these conditions. They describe cases in which carcinoma was suspected but could not be definitely diagnosed, which eventually proved to be malignant, and cases in which carcinoma was thought to be present, but subsequently were found to be hyperplastic gastritis. This corresponds to our own experience. Benedict (1) concludes that exploratory operation is indicated when malignant disease is merely suspected on gastroscopic examination.

We wish to present 3 cases in which the differential diagnosis between hyperplastic gastritis and polyposis or carcinoma was most difficult. In 2 of the cases, the roentgen findings suggested carcinoma and were supported gastroscopically in one. In the other, it was not available. In both of these, chronic hypertrophic gastritis was the final diagnosis. In the third case, roentgenological studies indicated the presence of a small polyp, but at later examination the stomach appeared normal. At gastroscopy, the possibility of malignancy was considered, but because of the negative roentgenological findings, a severe hyperplastic gastritis was favored. Subsequently, exploratory operation revealed the presence of carcinoma.

CASE 1. J. L., a man aged 46 years, was seen in consultation with Drs. Moffitt, Bender, and Firestone. Following an auto accident on May 10, 1938, soreness was present in the right anterior costal margin for 1 month. On July 18, 1938, there was onset of nausea and vomiting after meals at varying intervals, accompanied by a severe cramping pain in the lower abdomen. The vomitus was usually streaked with blood. A loss of 15 pounds occurred in 3 weeks. This condition became progressively worse until August 12, 1938, when he was hospitalized. Under 2 weeks of bed rest and a high protein diet, the attacks of vomiting decreased to one per day, usually several hours after the evening meal.

Physical examination revealed the presence of marked girdle obesity and evidence suggesting hypo-

Fig. 1. Case 1. Roentgenogram, August 15, 1938, showing the multiple irregular filling defects in the lower two-thirds of the stomach, suggestive of a polypoid neoplasm.

Fig. 2. Case 1. Photograph of the resected specimen before fixation, illustrating the marked mucosal hypertrophy and the tortuous, thickened, nodular folds.

pituitarism, hypogonadism and hypothyroidism. Definite epigastric tenderness was present. There was bilateral pitting edema of the lower legs.

Laboratory examination disclosed: hemoglobin, 80 per cent; red cell count, 4,700,000; white cell count, 12,600. Wassermann and Kahn blood tests were negative. Patient refused a gastric analysis, but the vomitus showed an absence of free hydrochloric acid, and a total acidity of 7. Stools contained occult blood.

Roentgenological examinations by Dr. L. Bryan showed the following: On August 15, 1938, the lower two-thirds of the stomach presented irregular filling defects, with diminished peristalsis (Fig. 1). A polypoid carcinoma was diagnosed, but the presence of a true polyposis or lymphoblastoma was also considered. Roentgen therapy was advised to rule out the presence of a lymphoblastoma. Re-examination 2 weeks later (August 26, 1938) revealed an increased number of multiple irregular defects extending from the pylorus almost to the cardia. A diffuse papillomatous tumor was diagnosed, showing no response

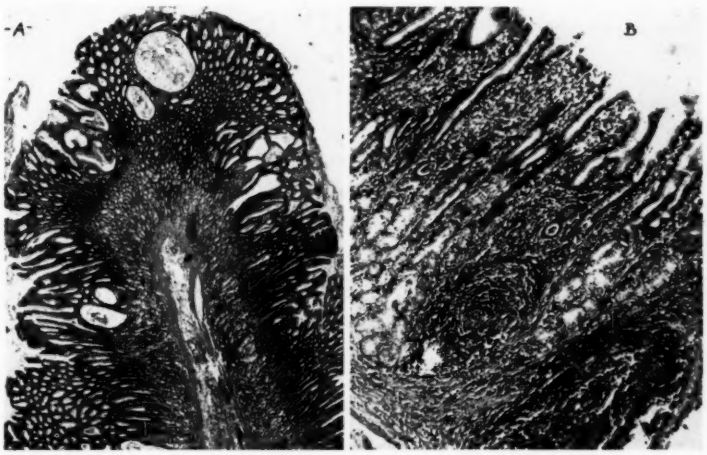


Fig. 3. Case 1. a, left. Section of an hypertrophied polypoid mucosal fold, with cystic and tortuous glandular alterations. b, Section of mucosa under higher power, illustrating the extensive infiltration of plasma cells and lymphocytes, and the hypertrophied lymphoid follicles.

Fig. 4. Case 2. Three small dense shadows are present on the posterior wall, in the middle third of the stomach, interpreted as ulcer craters. Fluoroscopically, there was evidence of infiltration in this region.

to radiation therapy. In view of the roentgen findings, a pre-operative diagnosis was made of carcinoma, probably inoperable.

Operation was performed on September 7, 1938, by the senior author. Palpation disclosed only a slight thickening of the gastric wall. There was no induration or enlarged glands, and the liver, pancreas, and gall bladder appeared normal. Anterior gastrotomy revealed the presence of very high, thickened mucosal folds, with intervening deep sulci (Fig. 2). Most of these ridges ran longitudinally, but one fold, about one-half inch wide, ran obliquely posteriorly. There was no evidence of a polypoid tumor. In the sulci there were scattered small, round, soft, circumscribed reddish areas, each about 5 millimeters in diameter. The folds were most prominent in the antrum and body and less elevated toward the cardia. No hemorrhagic areas were observed. A large amount of mucus was present. Although the presence of carcinoma was questioned, after deliberation a resection was performed. It was felt that such treatment would preclude the possibility of overlooking a malignancy. Also, if hyperplastic gastritis were present, resection might offer a cure of the severe symptoms which medical therapy had not accomplished. Prolapsed hypertrophic mucosa at the cardiac stump was removed to prevent obstruction of the stoma. Recovery was uneventful.

Pathological examination was performed by Drs. Rusk and Biskind. Grossly (Fig. 2), the resected specimen showed a very marked mucosal hypertrophy, with enormously thickened, tortuous, elevated, nodular folds. Microscopically (Fig. 3, a and b), there was evidence of a severe, diffuse, chronic hypertrophic gastritis. The nodular elevations and hypertrophied folds were composed of mucosa presenting very irregular proliferation, and sharply demarcated by the muscularis mucosæ. The crypts were elongated, with cork-screw formation and showed striking cystic degeneration. There was a dense infiltration of the mucosal stroma by lymphocytes and plasma cells. An increased number of hypertrophied lymphoid follicles were present in the mucosa but absent in the submucosa, and more frequent in the region of the nodular elevations than in the hypertrophied rugal folds. The normal epithelial elements were partially replaced by tall columnar

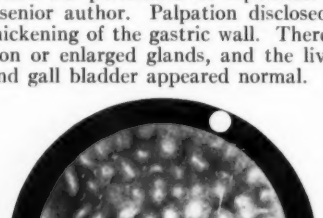
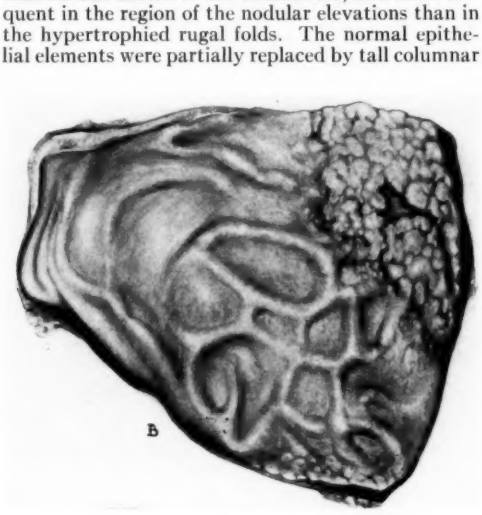


Fig. 5a



B

Fig. 5b

Fig. 5. Case 2. a, Drawing of the gastroscopic view, showing a thickened, nodular, ulcerated area on the posterior stomach wall, simulating tumor. b, Drawing of the resected specimen, before fixation, showing a localized thickened, nodular area on posterior wall, involving lesser curvature and extending to superior edge of specimen. An ulceration is present within this tumor-like area.

cells resembling the lining epithelium of the intestine. Oxyntic cells, especially, had been replaced. The submucosa was scanty and edematous, particularly where it was present in these enlarged folds. The muscularis was not thickened, but contained a few lymphocytes and plasma cells, especially around blood vessels.

Subsequent course: On October 13, 1939, 13 months after surgery, there were no digestive complaints, and a gain of 7 pounds in weight. A general diet was being followed. Roentgenological examination at this time revealed evidence of a resected stomach, emptying fairly rapidly through a rather large smooth stoma. The remaining portion of the stomach showed evidence of some diffuse hypertrophy of the gastric mucosa, most marked on the lesser curvature just above the stoma.

The history and roentgen findings suggested a polypoid malignancy. At exploration, a definite diagnosis could not be made, although a carcinoma was believed unlikely when the mucosa was exposed through a gastrotomy opening. The question arises whether a patient should be subjected to the serious operation of gastric resection without a positive diagnosis of malignancy. When the possibility of cancer is present, it always dominates the surgeon's mind. With the field exposed and without the assurance of a definite pathological diagnosis, most surgeons would hesitate to close the abdomen without removing the lesion. Frozen section study of gastric wall tissue obtained at biopsy is unsatisfactory for a reliable diagnosis. The tissue is more difficult to study, and there is no certainty that the most characteristic portion of the lesion has been obtained. Moreover, to await thorough study of the tissue obtained at biopsy, would necessitate a second operation in the event of a positive diagnosis of carcinoma. This procedure would cause unnecessary delay and make for a more difficult later operation, as all surgeons can appreciate. When resection is performed immediately, there is the great satisfaction of knowing that a possible malignancy has been removed. Also, from the experience of ourselves and others (8, 12), such treatment will usually relieve the symptoms of hyperplastic gastritis, which are frequently intractable to medical treatment.

CASE 2. I. C., a woman aged 49 years, was seen March 10, 1939, at the Mount Zion Hospital with Dr. S. Sherman. For 6 months, epigastric distress and postprandial nausea and vomiting had progressively increased, with a weight loss of 10 pounds. Vomiting gave definite relief, alkalies slight relief. Appetite remained fair. Physical examination revealed no abnormalities.

Laboratory examination showed: hemoglobin, 75 per cent; red cell count, 4,410,000; white cell count, 6,050. Stools were negative for occult blood. Wassermann and Kahn blood tests were negative. Gastric analysis, using histamine, disclosed free acid 20 after 30 minutes and a total acidity of 40.

Roentgenological and fluoroscopic examination by Dr. J. Levitin, March 14, 1939, revealed evidence of three ulcer craters on the posterior wall in the midportion of the stomach, with infiltration in this circumscript area (Fig. 4). There was two-thirds gastric residue at 6 hours. An ulcerated neoplasm was favored.

At gastroscopic examination, March 17, 1939, a funnel-shaped area of ulceration was observed on the posterior wall near the lesser curvature, the ulcer floor appearing hemorrhagic (Fig. 5a). The surrounding mucosa was pale pink in color, moderately nodular and definitely thickened, evidence of an infiltrative process. Superior to the site of ulceration

Fig. 6. Case 2. Section of a mucosal nodulation, showing extensive lymphoid follicular hyperplasia, cellular infiltration, and fibrous proliferation.

Fig. 7. Case 3. Drawing of the gastroscopic view of pylorus, antrum, and incisura, showing a very irregular, slightly nodular mucosa, thrown into thickened folds.

but within the nodular circumscribed area mentioned, two small erosions were observed. The roentgenological diagnosis of ulcerated carcinoma was confirmed, although the possibility of a severe hypertrophic gastritis had to be considered in the differential diagnosis.

Operation was performed by the senior author on March 20, 1939. A localized thickened area was felt on the posterior wall of the body near the lesser curvature. Some glands were felt in the lesser and greater omentum. The presence of a carcinoma was questioned by the relative softness of the involved area but could not be definitely excluded. Subtotal gastrectomy was performed, with uneventful recovery.

Pathological examination was made by Drs. Rusk and Biskind. Grossly (Fig. 5b), an area of very hypertrophied mucosa, 5 centimeters in diameter, was present on the posterior wall near the lesser curvature, extending to the superior edge of the specimen. The mucosa in this region exceeded twice the thickness of the adjacent mucosa, presenting a nodular or cobblestone appearance. A small ulceration was present within this infiltrated area, of moderate depth and with induration at the base. No other ulcerations were seen. Microscopically, there was a polypoid irregularity of the mucosa in the grossly hypertrophied region, an extensive lymphocytic and plasma cell infiltration of the mucosa, and a subacute ulceration penetrating through the muscularis mucosæ. There were multiple minute acute ulcerations. An increased number of hyperplastic lymphoid follicles penetrated and distorted the muscularis mucosæ (Fig. 6). The glands did not show the loss of the differentiated cellular constituents. The crypts were deep and slightly tortuous. The submucosa was moderately thickened as a result of edema, fibrous proliferation, and pronounced cellular infiltration. Two lymph nodes obtained from the lesser and greater omentum were hyperplastic. The pathological diagnosis was that of a localized chronic ulcerative hypertrophic gastritis.

Subsequent course: On January 15, 1940, 10 months after operation, the patient was symptom-free. Roentgenological examination on May 2, 1939, revealed no abnormalities other than evidence of a previously resected stomach.

In this case, as in the first, carcinoma was suspected roentgenologically. But in addition, the diagnosis was confirmed gastroscopically because of the thickened, nodular, ulcerated area observed. As in Case 1, chronic hypertrophic gastritis was the final pathological diagnosis. At operation, however, there was more evidence to support the possibility of carcinoma than in the preceding case. It is interesting to note that the lesion here was more limited in extent than in Case 1. A rather similar case of localized hypertrophic gastritis, mistaken for an infiltrating type of neoplasm gastroscopically, was reported from the Massachusetts General Hospital (13). The roentgenologists there differed in opinions, one interpreting the localized character of the lesion as an argument against the presence of gastritis and in favor of neoplasm.

Case 3. S. P., a man aged 62 years, was seen July 11, 1939, with Dr. S. Burre, Eureka, and Dr. J. Smith. The patient complained of epigastric distress after meals for 2 months, accompanied by slight distention. A bland diet and atropine afforded partial relief. There was no weight loss.

Physical examination disclosed a sthenic, obese male of healthy appearance, with slight epigastric tenderness.

Laboratory examination showed: hemoglobin, 84 per cent; red cells, 4,590,000; white cells, 6,650. Stools contained no occult blood. Wassermann and Kahn blood tests were negative. Gastric analysis, using histamine, showed an absence of free hydrochloric acid in 3 specimens, and a total acidity of 10.

Roentgenological examination elsewhere, 1 month before entry, revealed evidence of a small round filling defect 1 centimeter in diameter, at the junction of the middle and lower thirds of the stomach, near the lesser curvature, interpreted as a single polyp. Another examination was performed July 11, 1939, and the suspicious area was believed to be produced by a "redundant mucosa" and not by a true polyp. The mucosa appeared uninterrupted, and peristalsis was normal through this region.

Gastroscopic examination was performed on July 13, 1939, with the following findings: The mucosal aspect of the antrum and incisura was distorted owing to the presence of a very irregular, slightly nodular mucosa thrown into thickened folds (Fig. 7). On the posterior wall near the lesser curvature, above the incisura, a very hypertrophied and hyperemic fold projected itself prominently toward the lumen of the stomach. On the lesser curvature and anterior wall of the body, the mucosa was also thickened, irregular, and slightly nodular, with two small hemorrhagic areas observed. A diagnosis was made of a severe chronic hypertrophic gastritis involving the distal half to two-thirds of the stomach, most marked on the posterior wall at the junction of the middle and distal thirds, near the lesser curvature. No true polyp was observed. In the differential diagnosis, the presence of a diffusely infiltrating neoplasm had to be strongly considered. However, since the clinical history and roentgenological findings were compatible with a benign lesion, the presence of a severe chronic gastritis was favored, and observation was advised.

Subsequent course (communication from Dr. Burre, Eureka): Epigastric distress, flatulence, and belching progressively increased. A mass developed in the right upper quadrant of the abdomen, near the gall-bladder region. Roentgenological studies, No-

vember 8, 1939, revealed evidence of infiltration of the stomach wall, involving the distal third and extending along the lesser curvature posteriorly to the junction of the upper and middle third. Operation, November 13, 1939, revealed the presence "of an advanced carcinoma of the stomach, occupying the entire posterior wall, over an inch thick throughout and inoperable." A large metastatic lesion was observed in the liver. A biopsy revealed the presence of a scirrhous type of carcinoma. On November 17, 1939, the patient expired. Consent for autopsy was not obtainable.

This case presents the converse of the 2 other cases described, and shows that carcinoma may simulate gastritis, as has been observed by others (1, 2, 3, 14, 18). The first roentgenological examination suggested the presence of a single gastric polyp. Repeated examination elsewhere within 1 month demonstrated no definite lesion. It is interesting that gastroscopy at this time disclosed evidence of diffuse infiltrative changes, especially on the posterior wall. However, a severe hypertrophic gastritis was incorrectly favored, although a diffusely infiltrating carcinoma was considered in the differential diagnosis. Four months later, pronounced changes could be observed in roentgenological studies. The case re-emphasizes the fact that in certain instances gastroscopy, as well as x-ray examination, may fail in the differentiation of the two lesions.

SUMMARY AND CONCLUSIONS

Three cases are presented, in two of which a pre-operative diagnosis of gastric carcinoma was made when marked chronic hypertrophic gastritis was the pathological diagnosis. In the third case, a severe hypertrophic gastritis was favored, but carcinoma was discovered at subsequent operation. A fourth case, the first description in the literature of hypertrophic gastritis simulating tumor, is briefly discussed again 14 years later.

Chronic hyperplastic gastritis simulating carcinoma is probably more prevalent than has been suspected. The increasing number of cases reported recently supports this belief. Gastroscopy has stimulated more interest in this subject.

The differential diagnosis between severe hyperplastic gastritis and carcinoma may occasionally be difficult or impossible, not only by roentgen and gastroscopic examination, but also at surgical exploration. It should be emphasized that unusual cases such as these in no way detract from the value of gastroscopy as a diagnostic aid.

A knowledge of this subject is of importance to the surgeon. When the diagnosis is doubtful, exploratory operation is definitely indicated. If this procedure does not furnish the answer, resection appears advisable to avoid the danger of overlooking a malignancy, as well as to establish the final diagnosis.

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THE EFFECT OF REPEATED PREGNANCIES ON RABBITS WITH RENAL HYPERTENSION

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THE hypertensive syndromes which occur during pregnancy have been a great source of annoyance to those clinicians and obstetricians who have tried to classify them with regard to symptomatology and to prognosis, both immediate and remote, for mother and fetus. In the human the co-existence of pregnancy with hypertension or renal disease is believed to be harmful to the kidney and vascular system of the mother and to carry an extremely poor prognosis for the fetus.

The production of chronic renal disease in the experimental animal has been very difficult and uncertain by most of the methods usually used to produce renal injury. Uranium nitrate, mercuric chloride, bacterial toxins, and nephrotoxic serum all produce substantial renal lesions of an acute nature but the chronic picture is difficult to attain, uncertain in quality, and but few of the animals live to attain a true chronic status. Hypertension is usually absent in animals in which renal injury is produced by these methods although x-ray and resection of a large amount of the functioning renal tissue do produce significant elevations of the blood pressure.

The recent development of a method which produces a marked elevation of the blood pressure with minimal amounts of demonstrable renal injury has paved the way for studying many of the phases of hypertension. The application of this procedure to the pregnant animal has been shown to produce a syndrome which resembles eclampsia in many features.

The syndrome produced by renal ischemia in the pregnant animal is strikingly similar to eclampsia in the human, and the course followed by these animals during subsequent pregnancies is not unlike that of patients with pregnancy complicated by hypertensive disease or chronic nephritis.

These factors have led us to attempt to determine what effect repeated pregnancies may have on groups of animals in which hypertension had existed for some time and to find out some of the factors which may have a bearing on the course of the disease as well as on the prognosis for the fetus.

MATERIALS AND METHODS

Twelve non-pregnant rabbits of 2.5 to 5 kilograms body weight and of varying breeds and ages were used as experimental animals. All were purchased from a local dealer and were healthy and disease-free as far as could be determined by the general condition and by the appearance of the viscera at laparotomy.

A control period of 3 weeks was carried out in which blood pressures were taken twice weekly by an indirect method,[1] urine[2] examinations for sediment, albumin, and specific gravity, and blood chemistry[3] studies were done weekly. In addition, the animal was weighed, the eye-grounds examined by the ophthalmoscope, and the general condition noted.

Following this control period the abdomen was opened under sterile technique and the aorta was constricted to degrees varying from

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[1]Following the local application of xylol to the ear of the rabbit, causing dilatation of these vessels, the auricular pulse can be palpated. After the concave surface of the ear has been packed with a firm, smooth bolus of cotton gauze a small cuff is applied around the base of the ear. Indirect blood pressure readings can then be made by palpation. These readings when checked with a mercury manometer against direct blood pressure readings obtained by cannulation of the carotid artery in 6 rabbits with normal blood pressures have shown variations of less than 10 millimeters mercury.

[2]Urine was tested qualitatively for albumin by the heat and acetic acid test; the specific gravity was determined by a calibrated urinometer; and careful microscopic examinations were done on sediment obtained by centrifuging at low speed.

[3]These studies consisted of measurements of non-protein nitrogen, uric acid, and urea. In a few animals cholesterol determinations were done by the method of Leiboff.

¼ to ⅔ of the original cross-sectional area by a silver wire loop both proximal and distal to the points of origin of the renal arteries.

For a period of 15 days after the constriction of the aorta had been carried out, the blood pressure determinations were done daily, urine examinations and determination of blood chemistry were carried out every other day, and the animals were weighed weekly. Following this initial period blood pressure determinations were done twice weekly, urine was examined weekly, and weighing was carried out at semi-monthly intervals. Blood chemistry determinations and inspection of the eyegrounds were carried out at monthly intervals.

All animals were kept on this regimen for periods varying from 1 to 9 months before being allowed to become pregnant for the first time.

After the first pregnancy had terminated, a control period of 1 month was observed before the next pregnancy occurred. When conception did not occur at the scheduled time, the animal was again exposed to the male at 15-day intervals until pregnancy or death occurred.

Fetuses were recorded as to length, condition, and number, and then discarded.

Following exposure to the male the abdomen was gently palpated twice weekly. Fetuses could usually be palpated after 12 days of gestation, and resorption could be determined after this time by failure of the fetal ovoids to grow or by their sudden decrease in size or absence.

Six animals were allowed to live their full life term and the 6 remaining were sacrificed by the intravenous injection of 2 cubic centimeters of 40 per cent formalin. Following death, a complete autopsy was done within 4 hours and sections of all viscera, glands of internal secretion, and, on some occasions, bone marrow were taken.

CONTROLS

Nine non-pregnant female rabbits with aortic constriction proximal to the points of origin of the renal arteries were included in control group 1. A preliminary control period similar to that described for the experimental animals was observed in this group. Following aortic constrictions of varying degrees, these animals were observed for varying lengths of time: 2 animals were observed for 9 months, 2 for 6 months, 2 for 4 months, and 2 for 3 months. Four of these animals died, and the 4 remaining, still in good health, were then used as experimental animals in the pregnancy series. One animal, followed for a year, was sacrificed.

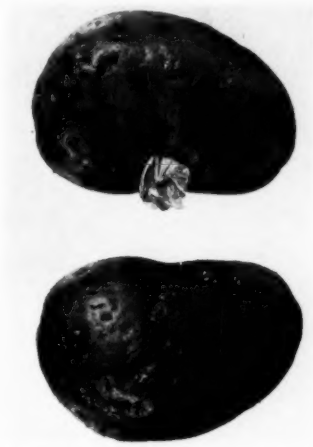

Fig. 1. Kidneys showing depressions of the cortex. No adherence of the capsule was noted here despite the marked "scarring."

Three female rabbits with aortic constriction carried out to reduce the lumen to ¼ of the original cross-sectional area distal to the points of origin of the renal arteries composed control group 2. Following a preliminary period of observation, 3 months for animal 1, 4 months for animal 2, and 6 months for animal 3, each of these animals was subjected to repeated pregnancies.

Clinical observations, blood pressure determinations, urine examinations, and blood chemistry estimations were studied in both control groups according to the schedule given for the experimental group and complete autopsies were done.

RESULTS

We are unable to make a definite statement regarding the effect on longevity of repeated

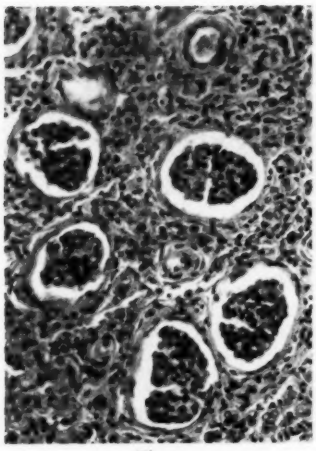

Fig. 2.

Fig. 2. Renal cortex showing an area of scarring with loss of tubular tissue, thickening of arterioles, and of Bowman's capsule. Note condensation of glomeruli. (Hematoxylin and eosin.)

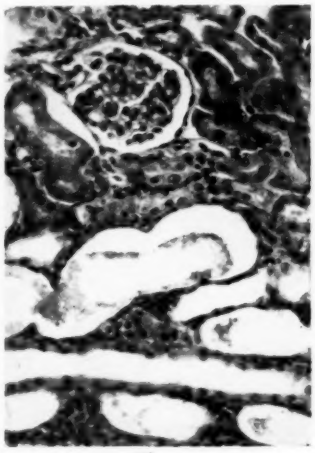

Fig. 3.

Fig. 3. Renal cortex showing tubular atrophy but no evidence of interstitial reaction. (Hematoxylin and eosin.)

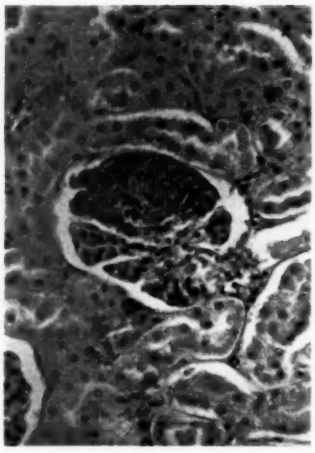

Fig. 4.

Fig. 4. Glomerulus showing hyalinization of one of the capillary tufts. (Hematoxylin and eosin.)

pregnancies in animals with renal hypertension because of the small series, the number sacrificed, and the presence of intercurrent pulmonary infection in several of the animals. We have gained the general impression that repeated pregnancy does have a detrimental effect on longevity. During the period of gestation no significant change in condition of the animals was noted, and when depression was noted it was usually seen immediately following delivery. Only one animal died while pregnant and but one immediately following delivery; the remainder died in the interval between pregnancies and the pathological findings in these animals were not unlike those of the remaining hypertensive pregnant animals.

Five of the animals conceived once and never again became pregnant. Three animals conceived twice: 3 had 3 litters: and 1 became pregnant 4 times.

Of the first pregnancies 58 per cent ended in resorption, 12 per cent in premature deadborn fetuses, and 30 per cent in term deliveries. Of the second pregnancies 28 per cent ended in resorption, 28 per cent in premature deliveries, and 44 per cent delivered living term fetuses. Fifty per cent of the third pregnancies were resorbed and the remainder went to term. The animal pregnant for the fourth time delivered normal living term fetuses. It seems that the multigravid animal has a slightly better chance of obtaining living term fetuses.

The degree of aortic constriction played a definite part in the outcome of the pregnancy. Of the animals with 4 plus constriction, 50 per cent of the pregnancies resulted in delivery of premature deadborn fetuses and 38 per cent in resorption of fetuses, while of those animals with 2 plus constriction, 46 per cent delivered term fetuses, 6 per cent premature deadborn fetuses, and 48 per cent resorbed the fetuses.

Little effect was noted in relation to the length of time hypertension had been present before pregnancy had occurred. In animals becoming pregnant 1 month following aortic constriction 25 per cent of the fetuses went to term while the remainder were resorbed. Of those in which 4 months had elapsed before pregnancy, there resulted 50 per cent term fetuses, 25 per cent premature, and 25 per cent resorbed. In animals in which 6 months had elapsed between constriction and pregnancy, 25 per cent went to term and 75 per cent resorbed: of those in which 9 months had elapsed, 50 per cent went to term and 50 per cent resorbed.

An increase in blood pressure was noticeable in all animals at the end of 1 month. Four animals averaged less than 20 millimeters mercury systolic pressure increase over the control level, 6 averaged 20 to 40 millimeters mercury systolic pressure increase, and 2 constantly maintained above 50 millimeters mercury increase in systolic pressure. All animals with 4 plus constriction maintained a pressure of above 150 millimeters mercury, 3 of the animals with 2 plus constriction maintained this level or better, while the one animal with 1 plus constriction rarely attained more than 140 millimeters mercury.

No definite effect of the presence of a pregnancy on the blood pressure findings was noted. It has been a noticeable but not constant finding that the blood pressure seems to be more unstable during the pregnancy, particularly the first one. As long as the animal remains in good condition, the blood pressure remains elevated and in a few animals there tends to be a gradual minimal increase in level.

Urine findings are for the most part negative during the earlier stages of the process. Albuminuria is noted at inconstant intervals in minimal amounts in the early stages of the hypertension and more frequently and in slightly greater amounts toward the end of the course, although usually no more than a heavy trace is seen. An increase in renal injury, as evidenced by more severe albuminuria or increased numbers of casts in the urine, was not noted during pregnancy.

Blood pressure and urine findings in representative experimental animals are presented in Charts 1, 2, 3, and 4[1].

The blood chemistry findings in both the pregnant and the non-gravid state showed no significant variation from the control values.

Weight and clinical condition usually ran parallel. With approach to term a gain in weight of 200 to 300 grams was noted, most of which was lost immediately following delivery.

Examination of the eye-grounds failed to show recognizable thickening of the vessels. Occasionally definite spasm was made out, although the labile condition of the rabbit's arterial tree makes subjective evaluation of spasm almost impossible. A moderate amount of tortuosity was noted to develop in 3 animals. No hemorrhages or exudates were seen.

[1] In the charts and in the descriptive material, 4-plus or severe constriction indicates reduction of the cross-sectional diameter of the aorta to ¼ 2-plus or moderate constriction, reduction to ½ and 1-plus or mild constriction, reduction to ⅘ of the original cross-sectional diameter.

PATHOLOGY

In general the animals showed some evidence of recent weight loss, and 2 animals were obviously chronically debilitated. In 2 animals small chronic stitch abscesses were noted, but in all no evidence of a generalized peritoneal or pleural inflammatory process was noted.

Heart. The heart showed marked left ventricular hypertrophy in 3 of the animals, moderate in 5, and no noticeable change in 4. Grossly, these organs showed no evidence of hemorrhage, scarring, or marked fatty change. The papillary muscles and chordæ tendineæ showed hypertrophy when the left ventricular muscle was definitely thickened. Microscopically, these myocardia usually showed no evidence of scars although in a few areas one gets the impression that there is a minimal amount of diffuse fibrous tissue proliferation and occasionally one finds small collections of round cells and fibroblasts.

Lungs. Two animals showed definite consolidation of the lung in which the Bacillus bronchisepticus could be isolated. In 6 of the remaining animals in which death occurred spontaneously, 4 had definite pulmonary edema, and in the 2 others no definite gross lesions could be made out.

Adrenal. The adrenals grossly were hypertrophied in 8 cases. This hypertrophy was confined almost entirely to the cortex and occurred bilaterally and equally. No adenoma formation was noted. The adrenal hypertrophy noted grossly was thought to be cortical for the main part and staining by scharlach R showed all layers of the cortex save the zona glomerulosa heavily packed with fat.

In 10 animals, cells or collections of cells were found containing fatty material and cholesterol clefts. These cells occasionally attained such proportions as to occupy 1/10 to 1/6 of the entire cross section of the gland. Areas of necrosis were present in 2 of these larger cell nests.

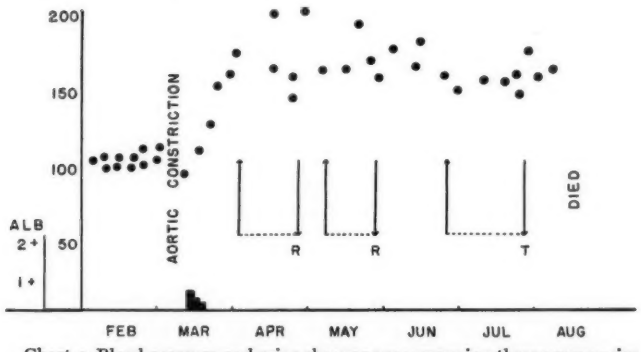

Chart 1. Blood pressure and urine changes accompanying three pregnancies in an animal with moderate constriction of the aorta proximal and distal to the points of origin of the renal vessels. The first pregnancy in this animal occurred 1 month following aortic constriction. (Rabbit No. 20.)

Note: In this and the following charts albuminuria is expressed as: Trace, Clouding after acid but not after heating; 1+, light granular precipitation after heating; 2+, moderate granular precipitation after heating; 3+, heavy flocculate precipitation after heating. ↑, indicates conception; ↓, indicates the end of the period of gestation; R, indicates resorption of fetuses; P, indicates premature delivery; T, indicates term fetuses delivered.

Liver. Grossly, the liver in these animals showed little deviation from normal. The size of the liver depended greatly on the state of nutrition of the animal. Spontaneous liver disease, coccidiosis, cholangitis, etc. were observed to a minimal degree in 2 animals. No cirrhosis of any type was noted and microscopic changes of significance in these animals were not encountered.

Kidneys. The kidneys of 3 of these animals showed no gross lesions while in the 9 remaining, there were definite multiple depressions occurring in both kidney cortices varying in size from 0.5 to 1.0 millimeter in diameter to 1.0 to 1.5 centimeters in diameter. They were dark, retracted, and resembled scarring of the kidney cortex with retraction (Fig. 1). It is of interest, however, that the capsules of the kidneys were usually not adherent to such areas of injury. The medullary portions and the pelves were not remarkable. No evidence of ureteral or pelvic dilatation or inflammation was noted.

Microscopic study of these kidneys showed areas which were characterized by condensation of the malpighian corpuscles with concentration of the nuclei in the glomeruli. Bowman's capsule was usually thickened and the tubules in these areas were seen only in remnants. The lining cells of these tubules were usually flattened and contained small dark nuclei. The lumina were dilated and

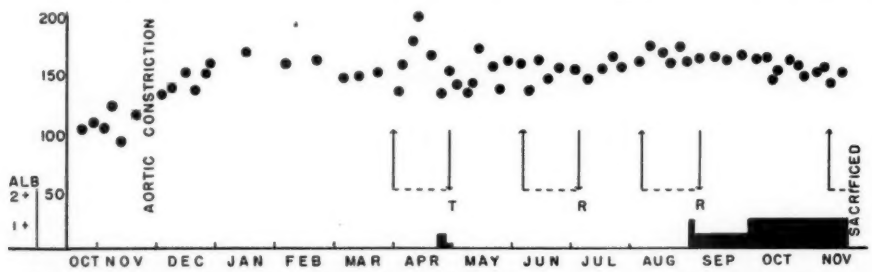

Chart 2. Blood pressure and urine changes in an animal following severe constriction of the aorta proximal and distal to the points of origin of the renal arteries during four pregnancies. The first pregnancy occurred 4 months following aortic constriction. (Rabbit No. 8.)

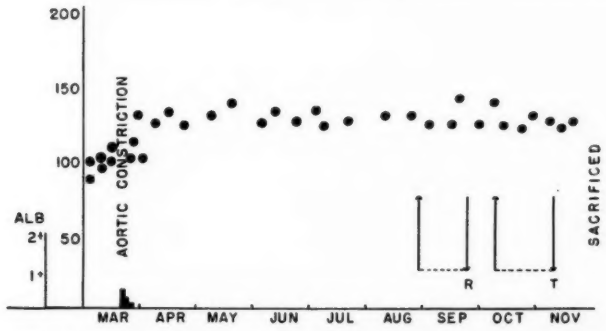

Chart 3. Blood pressure and urine findings during two pregnancies in an animal in which the aorta had been moderately constricted. The first pregnancy occurred 6 months following the development of hypertension. (Rabbit No. 21.)

usually contained hyaline casts. The interstitial tissue consisted of dense scar tissue with varying amounts of round cell infiltration. Arteriolar thickening was marked in such areas (Fig. 2).

In 6 animals definite areas of atrophy of the tubular epithelium were noted (Fig. 3). In 3 animals definite hyaline thrombi in several of the glomeruli were noted (Fig. 4). This was not a striking finding, however. Basement membrane thickening was carefully looked for and more than an occasional thickening of one tuft could not be demonstrated. Definite round cell infiltration of the pelvis and pyramids could be shown in only one animal.

Ovaries and uterus. No specific changes could be made out in these organs.

Aorta. Grossly, all but 3 of the 8 aortæ examined showed evidence of atheromatous plaque formation in the thoracic and upper abdominal aorta. These plaques varied in size from pin-point yellow flakes to flat yellowish, white shiny areas 3 to 5 millimeters in length, 1 millimeter in width, and were noticeably elevated. These were most noticeable in the arch and the upper thoracic portion of the aorta and frequently, although not exclusively, around the mouths of vessels.

Microscopically, the yellowish plaques described grossly showed that the intima was thickened by the infiltration of pale-staining, amorphous material with diffusely scattered nuclei of wandering cells. Fat stains on these plaques showed that the amorphous material contained a large amount of material which stained with scharlach R, most of which seemed to be contained in the macrophages. Elastic tissue stains showed definite reduplication and fibrillation of the internal elastic lamella in many of these areas.

Gut. No evidence of ulceration, hemorrhage, or membrane formation was noted and, microscopically, the mucosal and the muscular layers were normal.

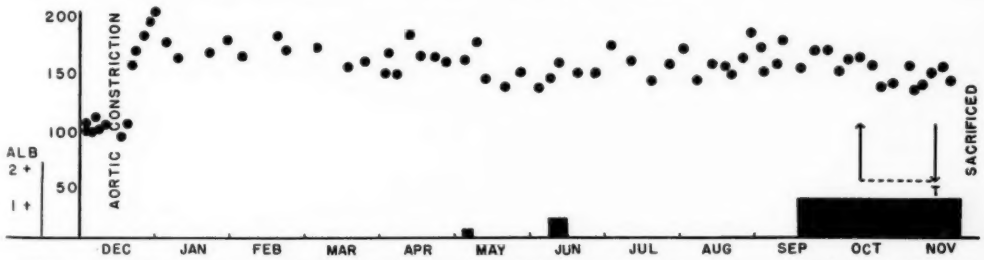

Chart 4. Blood pressure and urine findings in an animal with severe aortic constriction proximal and distal to the points of origin of the renal arteries followed by pregnancy 9 months after development of hypertension. (Rabbit No. 17.)

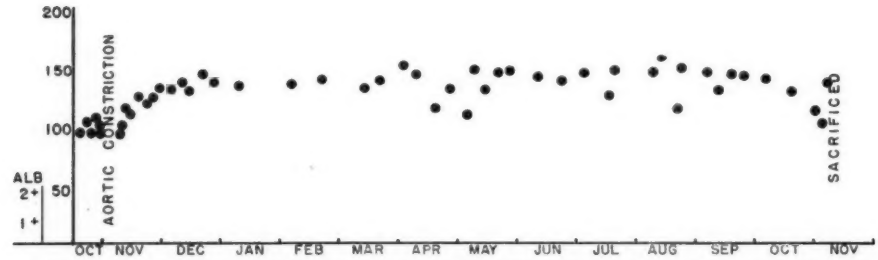

Chart 5. Blood pressure and urine findings in an animal with minimal aortic constriction proximal and distal to the points of origin of the renal vessels. (Rabbit No. 3.)

Parathyroids. In 3 animals a definite enlargement of the parathyroid tissue could be made out. This was not certain in the remaining animals in the gross, although 3 additional animals showed striking amounts of parathyroid tissue in sections of the thyroid gland.

No pathology could be found in the brain, pituitary, thyroid, or bone marrow.

CONTROLS

Control group 1. In this group were 9 animals with aortic constriction proximal and distal to the points of origin of the renal vessels and in which no pregnancy had occurred. The length of life in this group is not significant as it contained animals which died or were sacrificed early in the experiment. None of these animals was given an opportunity to become pregnant. All animals showed an increase in blood pressure. Two attained pressures which averaged more than 50 millimeters mercury above the control level and 2 averaged from 20 to 40 millimeters mercury above, while the 5 remaining maintained average pressures of less than 20 millimeters mercury above the control level. The general curves of blood pressure levels were identical with those of the experimental group.

Urine findings were usually negative; only 2 animals had mild albuminuria and cylindruria immediately following aortic constriction. Chart 5 shows the effect of this procedure on a representative animal. Minimum pressure elevation and no urinary changes were noted. Blood chemistry findings showed no significant variation from normal. Weight changes were not remarkable and the eye-grounds showed no significant changes.

All pathological changes noted in the experimental group were present in the 5 animals of this group which were examined but to a much less marked degree. This is easily correlated with the length of time these animals were hypertensive and with the degree of elevation in pressure sustained.

Control group 2. In this group were 3 animals in which aortic constriction had been performed distal to the points of origin of the renal vessels. The clinical condition and weight remained good and fairly constant throughout the experiment. All these animals were sacrificed. In none was a significant persistent elevation of blood pressure noted, although one animal showed a low grade elevation of pressure beginning 20 days following aortic constriction and lasting approximately 1 month. The urine remained constantly negative for albumin, cells, and casts. Blood pressure and urine findings during the experiment are demonstrated for a representative animal in Chart 6. Weight changes were noted only during pregnancy and were similar to those noted in the experimental group. Eye-grounds showed no significant variation from normal. No deviation from normal was produced in these functions by pregnancy. The positive findings at postmortem were limited to a minimal spontaneous nephritis. The aortas were searched for atheromatous plaques and none found.

ANALYSIS OF STUDY

We are at a loss to explain why reducing the renal blood flow in the pregnant animal produces a fatal vasospastic syndrome while pregnancy in the animal with reduced renal blood flow produces little, if any, effect.

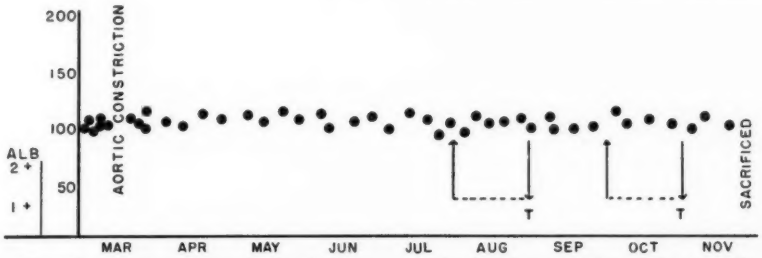

Chart 6. Blood pressure and urine findings on an animal with constriction of the aorta distal to the points of origin of the renal vessels. Two pregnancies were experienced during this period, both of which went to term. (Rabbit No. 37.)

It seems probable that the life expectancy of hypertensive animals is decreased by repeated pregnancies. The cause of death is usually a secondary infection which has superimposed itself upon general debility. It seems likely that cardiac failure, vascular accident, and renal failure would account for a fair proportion of the deaths, as is seen in the human with hypertensive diseases and eclampsia, had not early death taken place by secondary causes.

Fetal prognosis is quite poor in these animals, only 40 per cent of the pregnancies resulting in living term fetuses. This is quite similar to the condition existing in the human with chronic nephritis in which a similar high fetal mortality rate is noted. The mechanism for this low proportion of living fetuses, both in the rabbit with hypertension and in the human nephritic that suggests itself is anemia to the uterus by the severe vasospasm which leads to placental anemia and infarction and fetal death with expulsion or resorption.

The length of time elapsing between the production of hypertension and the first pregnancy, and the degree of hypertension seemed to play no part in prognosis for the fetus, although there seems to be a definite increase in number of term fetuses with succeeding pregnancies and with minimal degrees of aortic constriction.

It is noticeable that the degree of aortic constriction is usually parallel to the degree of hypertension, the incidence of albuminuria, the degree of renal damage, cardiac hypertrophy, and the degree of atheromatous plaque formation in the aorta. All of these factors were also accentuated by time when more than a minimal amount of hypertension existed.

We have been unable to demonstrate that repeated pregnancies alter the course of these hypertensive animals. No evident change in the blood pressure levels can be demonstrated and urine findings show no significant changes when compared with control animals with the same degree of injury. An attempt was made to do renal function tests, but these were considered of no value due to the remarkable variations in clearance values obtained in control animals. This failure to find a rise in tension and increase in albuminuria seems to be in direct contrast to what is found or believed to be true with the human with chronic nephritis in which the classical course is a rise in blood pressure during the early parts of pregnancy to a fall during delivery but to a level a little higher than that noted before the pregnancy.

The pathological findings, particularly of the kidney, aorta, and adrenals, are noteworthy.

The failure to demonstrate arteriolar changes in the eye-grounds of these animals is disappointing but perhaps not strange, as the labile vascular system of this animal makes objective determinations of this nature difficult in minimal grades of arteriolar thickening. The changes in the arteriolar tree in other portions of the animal, however, bear comment as moderate amounts of thickening are quite definite in the brain and kidney.

We believe that these studies have definite bearing on the attempt to link the toxemias of pregnancy and their sequelæ to the nephroscleroses by a common etiological agent.

The most recent and probably the most satisfactory classification of the toxemias of pregnancy has been based on the degree of hypertension, albuminuria, and vascular and renal damage as evidenced during and following pregnancy. In the follow-up of such patients one is impressed with the evidence that, although many have further pregnancies with no evidence of hypertension or vascular and renal pathology, in others the disease has not ceased with the delivery of the baby, since as many as 50 per cent develop what is later classified as essential hypertension, chronic nephritis, or one of the subdivisions of this group of syndromes. We are also cognizant of a small group of these patients who have mild toxemia of pregnancy with the first baby, essential hypertension with the following, and chronic nephritis with the third. There seems to be little doubt that in most patients repeated pregnancy tends to accentuate this rate of progression.

It seems likely that the severity of the toxemia parallels the degree of reduction of renal blood flow which occurs *during gestation*, and that the subsequent course is determined by the renal and vascular status prior to pregnancy *in addition to* the permanent vascular damage produced by the prolonged vascular spasm associated with that type of gestation.

CONCLUSIONS

Repeated pregnancies in rabbits with varying degrees of hypertension produced by renal ischemia have no noticeable effect on blood pressure, albuminuria, or histological renal changes.

The life expectancy of these animals seems to be decreased.

Fetal resorption and death occurs in a large percentage of these animals.

Adrenal, renal, and aortic histological changes are reported.

The evidence for a common etiological agent of the "toxemias of pregnancy" and the nephroscleroses is supported.

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NASAL SIMULTANEOUS GASTRODUODENAL ASPIRATOR

Its Use in Postoperative Gastro-Intestinal and Abdominal Surgery

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THE nasal gastroduodenal aspirator finds application in many gastro-intestinal and abdominal surgical conditions, particularly in intestinal obstruction.

Intestinal obstruction is a condition in which fecal movement is prevented or impeded by either complete or partial occlusion of the bowel lumen. The primary cause is entirely mechanical and is due to a blocking of the lumen of the bowel from within or to compression from without, with the exception of those conditions which produce paralysis of the muscular wall of the bowel. This latter type, which is known as the paralytic form, may be reflex or toxic due to inflammations, intestinal trauma, or shock.

Intestinal obstruction brings on a group of symptoms and signs, the most important of these being colic-like intermittent pain, vomiting, and distention. Vomiting is an early and prominent symptom and usually projectile in character with the onset of obstruction. It comes on long before regurgitation of intestinal contents into the stomach takes place. If the obstruction is high, the damming back of digestive juices results in a regurgitant type of vomiting which is accompanied by nausea and is continuous whether or not food or fluid is given by mouth. True fecal vomiting is rarely observed.

On the other hand, in low obstruction, vomiting is a late feature and may be absent throughout the course of the disease. Vomiting causes a loss of body fluids, dehydration, and with it is associated a disturbance of the physicochemical balance manifested chiefly by the loss of sodium and chloride ions.

In low obstruction, the usual sign is distention. The sequence of events in the production of distention is as follows: At the site of the obstruction, the advance of fecal material is halted, thus producing a stasis. To overcome this stasis an increase in the intestinal peristaltic action takes place along with an increased outpouring of secretions from the neighboring organs. With this added secretion there is an accumulation of gas, the source of which is essentially swallowed air, also air that has diffused through the intestinal wall and gas that has formed from fermentation, putrefaction, and decomposition of ingested foods.

In normal conditions, 90 per cent of this gas is absorbed and exhaled through the lungs, and the remainder is expelled by way of the rectum. In intestinal obstruction, however, there occurs a decrease in, or an absence of, the absorptive capacity of the intestinal mucosa which causes fluids and gases to accumulate above the point of obstruction, thus augmenting the intra-intestinal pressure which then gives rise to distention. The nonabsorbable gases are usually methane, hydrogen, nitrogen, and the tertiary amines, constituting the bulk of gases causing distention.

If this increased distention remains uncorrected for any length of time, vascular changes and necrosis of the bowel wall will inevitably result with the development of an ever-deepening toxemia.

In spite of the great advances made in medicine and surgery, and notwithstanding the great progress made in our knowledge of that condition, and in our clinical observations, physical examination, and in the introduction of new methods, intestinal obstruction remains one of the most serious conditions confronting the profession, and, while there has been a substantial decrease in its mortality, the death rate still continues to be appalling.

The literature is replete with data gathered by surgeons from hospital records which show a high death rate from intestinal obstruction, the average being between 60 to 75 per cent. up to 1926.

Best in his article reports Guillame's statistics of a mortality of 63.2 per cent in a

series of 3,269 cases, Arhurst's 69.3 per cent in 346 cases, and Lee and Downes' figures of 75 per cent. C. Jeff Miller, of the New Orleans Charity Hospital, found a gross mortality of 61 per cent in 343 cases of intestinal obstruction. A substantial decrease in the death rate is revealed in the later statistics of Moss of the same institution covering the period from 1930 to 1934 who found in a series of 340 cases a mortality of 31.7 per cent, or less than half of Miller's series. On the other hand, Boyce, continuing these studies and covering the period from 1933 to 1936, reported a slightly higher mortality of 36.3 per cent. Van Buren and Smith found that the mortality of acute cases in their hospital dropped from 66 per cent in the 5 year period from 1919 to 1924 to 29.6 per cent in 1932 to 1937. Burgess, of London, found that in the 1,042 cases of intestinal obstruction studied by him, 395 patients died, or a gross mortality of 37.9 per cent. North, of Philadelphia, collected his mortality statistics from a series in the literature totaling 1,625 cases including 200 patients of his own, of whom 425 died, or a gross mortality of 29.2 per cent.

This substantial lowering of the mortality, as revealed by the above data, was due to a number of factors, such as improved medical skill in diagnosing the condition, early operative intervention and the selection of the optimum time, since it became apparent that intestinal obstruction must be relieved before distention had progressed to such a degree that it would interfere with the blood supply of the bowel. Rehabilitation of the patient was found to be of prime importance and this was accomplished by the administration of fluids in the form of glucose solutions either subcutaneously or intravenously to overcome dehydration which reduces the nonprotein nitrogen of the blood, promotes diuresis, and enhances the liver's detoxifying function. The induced hypochloremia was corrected by giving sodium chloride in sufficient amounts to raise the blood chloride level, thus increasing peristalsis and augmenting the tone of the bowel. Gastric lavage, before operation, removed a considerable amount of the protein disintegration products responsible for the production of the toxemia.

In addition to these factors, a major part in lowering the mortality from intestinal obstruction was played by decompression. The oldest method of decompression was that of blind puncture of the distended loops of the bowel by means of a needle or trocar. A more controlled method of decompression—enterostomy—has been practiced with greater success in the last 75 years.

The modern conception of the term decompression relates to the use of tubes introduced into the gastro-intestinal tract by way of the nasal or oral routes. This method of effecting relief of distention is, likewise, not new. Kussmaul and Cahn, in 1884, first used an elastic stomach tube for aspirating purposes and reported that such a form of treatment diminished the intra-abdominal pressure, reduced the size of the bowel proximal to the point of obstruction, and retarded violent peristalsis.

With the advent of the small calibered tube, gastric and duodenal drainage was greatly facilitated. Westermann, in 1910, reported the use of such tubes by the nasal route for continuous drainage in cases of ileus associated with peritonitis and stated that such a method of procedure was first used by Tannier in the year 1888.

Levin, in 1921, introduced a tipless gastroduodenal catheter tube, suggesting the nasal route in place of the oral for introduction. The tube had a velvet edge at its terminal end, exactly like a urethral catheter, No. 14 to 16 French, with a few oval side openings at its end. He claimed that the employment of this nasal route in its introduction eliminated any discomfort or choking sensation on the part of the patient. The nasal route has not found much favor among gastro-enterologists in this country who contend that the oral method was far more preferable. They also claimed that for successful intubation of the duodenum the tube required weighting at its terminal end, so as to keep it in its proper place along the stomach pathway in its progress to the pylorus and to accelerate its entrance into the duodenum. The tube, in the course of the following few years, found its greatest application in surgery, and achieved its greatest popularity in postoperative drainage.

Ward, in 1925, advocated the use of gastric intubation with suction in the treatment of intestinal obstruction.

McIver and his co-workers, in 1926, used small calibered tubes as a prophylaxis in the postoperative treatment of ileus, demonstrating that the presence of gas was due largely to swallowed air.

For the past 20 years, Wangensteen has interested himself in the problems of intestinal obstruction, engaging in extensive experimental studies, the results of which he has applied clinically. As a surgeon, he has had the opportunity to operate in a number of obstructive intestinal cases, using the decompression method in all of them. His method of decompression consisted, at first, in introducing an ordinary Levin nasal tube at the end of which was attached a suction siphonage apparatus. It soon became apparent, however, to Wangensteen and his coworkers that such a tube when placed in the stomach would not keep that viscus continuously empty and would be effectual only intermittently as the stomach filled again. Moreover, drainage of the duodenum could not be accomplished, except when there existed regurgitation of the duodenal contents back into the stomach, because the activity of the pyloric sphincter usually interrupts the continuity of the stomach and small intestines as a single tube. Besides, in order to accomplish a successful intubation of the duodenum for decompression, it was necessary to weight its terminal tip so as to accelerate its entrance through the pylorus into the duodenum. In order to obtain a successful decompression, they realized the necessity of siphoning both the contents of the stomach and duodenum at the same time.

Keeping these points in mind, Wangensteen and his co-workers (17) modified the ordinary nasal tube by having the last 4 inches of the terminal end of the tube impregnated with lead to facilitate its entrance into the duodenum. They also increased the number of openings, placing 9 of them in the last 10 inches of the tube in the belief that, with the anchoring of the terminal end in the duodenum, continuous suction siphonage could be executed simultaneously from the stomach and from the upper reaches of the intestinal canal. Whether this could be really accomplished will be discussed later.

Intestinal decompression is a valuable preoperative measure in obstruction of the lower small bowel while preparations for surgery are being made. First, it allows gastric lavage which can be repeated until the return fluid is clear. Then the tube may be advanced further into the duodenum, thereby removing accumulated liquid and gaseous material from the upper bowel and in this manner reducing or minimizing the degree of toxic resorption. Such decompression also obviates vomiting and prevents distention. It is of distinct advantage in that it decompresses the bowel gradually rather than abruptly, and thus reduces the intraluminal pressure before irreparable damage is done, while, at the same time, it permits the intestines and stomach to contract. By such means, the patient's general physical condition is improved and he becomes a better surgical risk; the surgeon may open the abdomen calmly and do the necessary surgery with assurance that the individual will pass through the ordeal without the danger of gangrene or rupture of the bowel.

After operation, decompression is of enormous value, not only in relieving distention and in draining the bowel, but also in protecting it, as it were, until it can regain its normal tone. By keeping the stomach empty, nausea and vomiting after operation are eliminated, the patient is comfortable, as proved by the figures of Wangensteen (17), who reduced the incidence of the symptoms by suction siphonage from 90 to 15 per cent. Decompression undoubtedly has added to the operative safety of the patient in acute intestinal obstruction and to his postoperative comfort.

Thus it is seen that decompression at times offers a means of relieving the patient's distention, without operation. This procedure makes it also possible to delay surgery safely until the patient's general condition is improved and his fluid and chemical balance becomes normal. Operation then becomes a procedure of election rather than one of emergency. The technical difficulties attendant

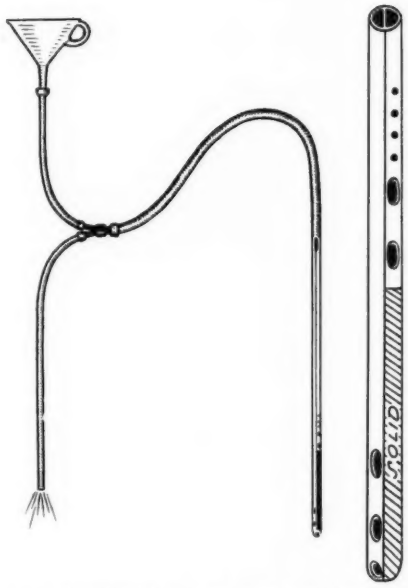

Fig. 1. Author's double channel esophageal lavage tube.

upon the operation on distended loops is removed.

Soon after Wangensteen's enlightening contributions came the illuminating work of Abbott, Miller and Johnson (12). They designed a double lumen tube, the basic principle of which is the same as that which had for some time been used in colonic irrigations. The larger channel which serves as an aspirator, extends distally to the perforated tip attached to the end of the tube. The smaller channel serves as a passage for air for an inflation balloon placed at the terminal end. After the tube had passed the pylorus the balloon is inflated and peristalsis carries its end to the point of obstruction. They claim that their tube offers the possibility of extending the efficacy of suction-drainage by affording drainage at the bottom rather than at the top of a distended column of fluid and gas.

A detailed analysis of the advantages and disadvantages of this tube and its rôle in decompression will be in a separate paper describing the author's new intestinal aspirator.

Decompression can be used either as an adjunct to surgery before operation or after

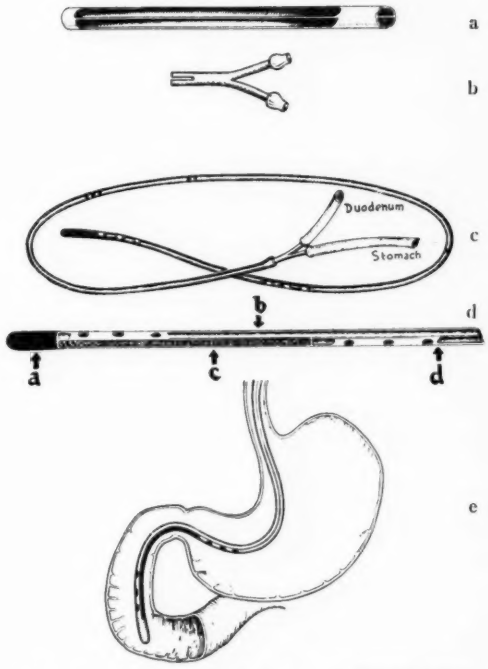

Fig. 2. Author's nasal simultaneous gastroduodenal aspirator.

operation, or, in some cases, can replace surgery entirely. This paper does not deal with the problem in which types of cases decompression should be used alone or as an adjunct to surgery—that is for the surgeon to decide. My concern here is to present a new tube which will achieve a most effective decompression.

In the course of my work in gastro-enterology, I felt the need for a tube that would make possible the obtaining of a simultaneous specimen from the stomach and duodenum. There are on the market a number of tubes for such a purpose and nearly all of them consist of a shorter tube fused or vulcanized to a longer tube and have at their end a metal bucket. Such a tube does not permit nasal intubation, and is too bulky even for oral introduction and too uncomfortable for retention by the patient for long periods of time.

In 1939, in my article on "The Treatment of Cardiospasm"(7), I described a double

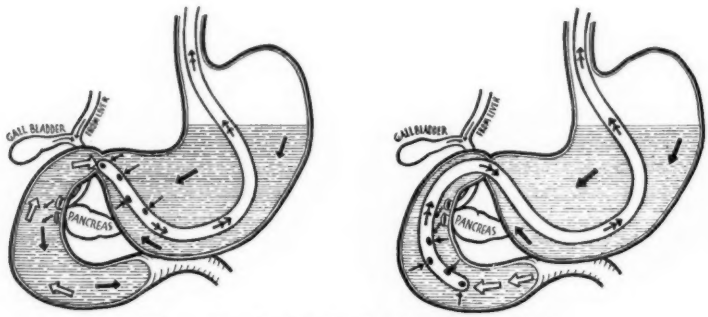

Fig. 3. The rôle of the Levin tube in decompression.

lumen tube for esophageal lavage (Fig. 1). The tube is No. 28 French, 30 inches in length and bisected into two distinct canals. One of the canals terminates at a point 4 inches short of the tip, while the remainder of its lumen is filled with solid rubber. Immediately above this solid portion, the walls feature a few wide openings. The second canal extends to the very end of the tube and has at its terminal end a few oval perforations. The idea occurred to the author that by incorporating this principle we would have a very simple simultaneous nasal gastroduodenal aspirator.

This tube (Fig. 2, c) is 50 inches in length, No. 16 French, semi-soft in consistency, flexible, and of good resiliency. Its lumen is equally divided into two channels, semilunar in shape (Fig. 2, a), and terminates in a catheter-like tip which is made of solid lead-impregnated rubber for a distance of 2½ inches (Fig. 2, d*a*). The duodenal side (Fig. 2, d*b*) of the double channel extends down to the solid rubber tip and has 3 oval openings slotted in appearance and ½ inch apart. The gastric side (Fig. 2, d*c*) of this double channel ends at a point about 7 inches above the solid rubber tip, the remainder of its lumen is filled with lead shot (Fig. 2, d*d*). Immediately above the lead-filled portion, there are 3 openings, oval in shape and ½ inch apart.

The tube has a one-ring mark placed at 19 inches, which represents the distance from the nares to the cardia; a two-ring mark at 30 inches which is the distance from the nares to the pylorus and a three-ring mark at 36½ inches from the tip. This permits 6½ inches of the terminal end of the tube to enter the duodenum and leaves a space of 3 inches from the lower opening of the gastric channel. It is understood, however, that the physician's judgment should always determine the length of the tubing necessary for each individual, and he should not always rely entirely on the markings.

The special double channel connector (Fig. 2, b) consists of two narrow metal tubes soldered together in the middle, and branching off distally into two separate canals, each of which is cemented into the proximal opening of the tube to render it airtight. Proximally, the connector bifurcates into two channels, one representing the gastric outlet and the other the duodenal (Fig. 2, c).

Normally, as it is well known, the duodenum receives the greatest flow of digestive secretions where the openings of the common and pancreatic ducts are located. These secretions are mixed with the products of gastric digestion and pass into the small intestine where the final stage of digestion takes place. The greatest portion of the products of digestion is absorbed in the intestines and the remainder travels on to the colon.

However, in intestinal obstruction, the advance of fecal material is halted, and a stasis of the accumulating food material is produced. To overcome this condition, there is an increased intestinal peristalsis together with a compensatory increase in secretion from the neighboring organs and gut. The intestines receive an increased volume of fluid material together with the accumulated gas, which is essentially swallowed air, and the end products of fermentation and putrefaction.

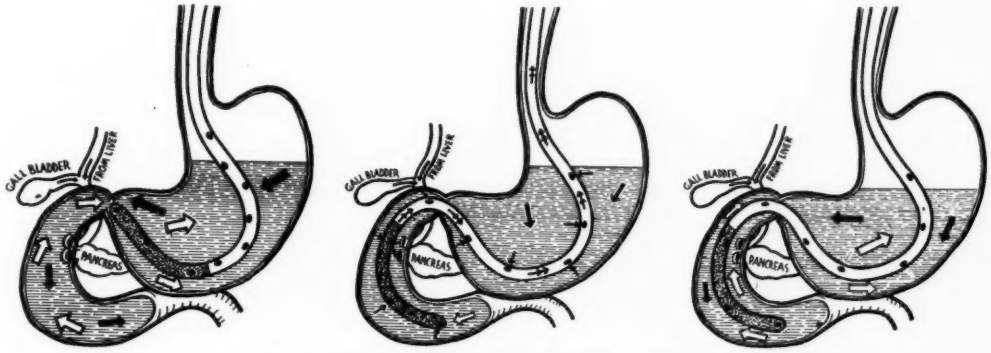

Fig. 4. The rôle of Wangensteen tube in decompression.

There occurs, at the same time, a decrease or absence of the absorptive capacity of the intestinal mucosa. This acts as a contributory cause of accumulation above the point of obstruction and augments the intra-enteric pressure that gives rise to distention. As soon as this column of accumulated material extends to the higher reaches of the duodenum, there is a retroregurgitation through the pylorus into the stomach with subsequent vomiting.

In order to eliminate vomiting associated with intestinal obstruction, surgeons and clinicians have employed siphonage by means of small calibered tubes introduced through the nose, particularly the Levin tube.

To understand the exact rôle that each of the tubes plays in siphonage, I have prepared a set of diagrams which clearly illustrate what each tube actually accomplishes in bringing about decompression.

THE RÔLE OF THE VARIOUS TUBES IN DECOMPRESSION

Let us now proceed to the evaluation of the principal tubes that lend themselves to application in drainage of the stomach and duodenum.

The Levin tube. This tube has four openings at its terminal 2½ to 3 inches. When propelled forward, and on reaching the fundus of the stomach, it will permit the sucking out of gas bubbles by the application of a suction siphon. In its further progress within the stomach the Levin tube will remove all the accumulated fluid. This is shown in the accompanying diagram (Fig. 3, a, left) by the black arrows pointing toward the openings. The double arrows show the direction of the aspirated fluid within the tube on its way out.

It will be seen, however, that the Levin tube, being a single tube, will not simultaneously drain any duodenal contents except those that enter the stomach from time to time by way of regurgitation as shown by the white arrows. It will only drain the duodenal contents alone when it enters that part of the gut. Parenthetically, it may be remarked here that the Levin tube, not being weighted, is not very efficient in reaching the duodenum with speed and promptness. Most gastroenterologists agree that weighting *does* promote and accelerate the transit of a drainage tube into the duodenum. The absence of weighting detracts markedly from that function of the tube.

Now let us assume that the Levin tube has entered the duodenum in the course of its progress. Drainage then takes place through it, as shown in diagram (Fig. 3, b, right). The drainage fluid in the duodenum consists of biliary and pancreatic secretions, besides its own, and regurgitated fluid from the jejunum, as shown by the white arrows. However, nothing can be drained from the stomach at the same time, neither gas nor fluid, save that which has passed through the pylorus into the duodenum during normal peristalsis. Thus no combined gastric and duodenal drainage is possible through the Levin tube.

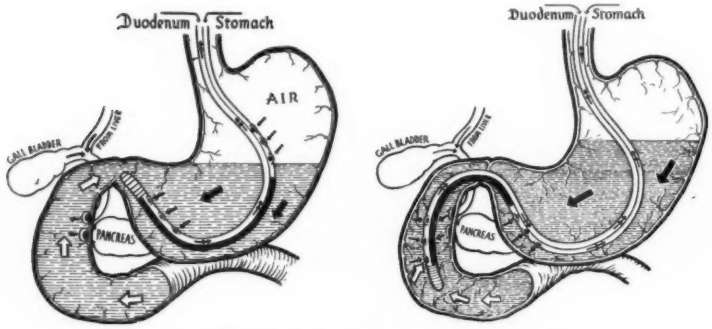

Fig. 5. The rôle of author's tube in decompression.

Wangensteen tube. This tube is claimed by its proponent to give a very efficient performance in actual drainage and decompression of the stomach and duodenum. Wangensteen states that his tube, when placed in the stomach, is capable of withdrawing all the fluid and gas in that viscus. When the tube is in the duodenum, he claims that it provides a continuous and simultaneous withdrawal of liquid and gas from both stomach and duodenum.

How true is that claim?

On actual testing of that tube *in vitro*, these desired results are unfortunately not obtained, as any one can convince himself by actual experiment. The reason for this failure is as follows: It will be recalled that the Wangensteen tube has 9 openings in its terminal 10 inches. However, the usual measurements of the average normal stomach from cardia to pylorus is 11 inches. All the duodenal tubes are marked in accordance with this fact. The distance from the nose to the cardia is 19 inches, from nose to pylorus, 30 inches. Let us suppose that the Wangensteen tube has been introduced up to the 30 inch mark. This should bring the tube right to the pylorus and should leave its entire terminal 10 inches in the stomach. On actual drainage, however, very little comes out except a little air of the gas bubble. The reason is that *no fluid will drain out if any of the openings are placed above the fluid level.* Because of the many widely spaced openings in the terminal portion of that tube it suffices that only one of these openings be above the fluid level to prevent any drainage of fluid through it. This is a well recognized and old established physical law.

On accompanying diagram (Fig. 4, a, left) this is indicated by the absence of double arrows from the tube, showing no drainage stream within it. If through regurgitation from the duodenum fluid accumulates in the stomach so as to raise its level above the highest opening, drainage will take place only so long as that highest opening is below the level of the fluid. Should sufficient fluid be drained off to cause the highest opening of the tube to emerge above the fluid level, *drainage will immediately cease.*

When the Wangensteen tube advances into the duodenum, i.e., to the final 32 inch mark, its final 4 inches lying in that viscus *under* the fluid level, and the upper openings being in the stomach *below* its fluid level, *then and only then* will simultaneous drainage from both duodenum and stomach take place. This is indicated in the diagram (Fig. 4, b, center) by the black arrows. The white arrows show the regurgitation from the jejunum into the duodenum, the double arrows show, as before, the direction of the stream of drainage within the tube.

However, no sooner does the level of the fluid within the stomach drop and the uppermost openings emerge above the fluid level then drainage promptly stops. This is indicated in the diagram (Fig. 4, c, right) by the absence of double arrows within the tube.

Now let us imagine that most of the openings of that tube are in the duodenum and

that some are in the stomach and that full emptying of the stomach has taken place. As soon as one opening within the stomach emerges above its fluid level, then no fluid can be drained from the duodenum, in spite of the fact that most of the openings of the tube are within it. In other words, the fluid is trapped within the duodenum.

In vivo this law, as outlined above, holds too. However, we must admit that when used on the living patient we may often achieve a partial drainage with the Wangensteen tube in the normal or hypertonic individual. This is due to a number of factors that cause a narrowing of the contour of the stomach and a consequent rise of its fluid contents above the uppermost opening on the tube. These factors are: active peristalsis, a good muscular tone, good diaphragmatic action, deep respiration, etc. However, complete drainage is *never* achieved. This I was able to verify by barium studies on patients through the fluoroscope.

But in the pathological conditions of the stomach, such that cause atony or dilatation, in pyloric or intestinal obstruction from any cause and other similar factors, drainage through the Wangensteen tube will depend upon whether the upper openings are below the fluid level.

Author's tube. My own double tube for simultaneous gastric and duodenal drainage is designed to overcome this defect of the Wangensteen tube. In the first place, my tube has two independent channels, one, the lower channel—the duodenal side—has 3 openings in its final 1½ to 2 inches. The upper channel—the stomach side—is placed 9½ inches from the terminal tip of the tube. It has likewise 3 openings which extend for 1½ inches. This channel represents the gastric side.

When this tube is passed to the fundus of the stomach it will immediately remove the air of the gas bubble. On further advance within the stomach, as soon as its terminal 2 inches are submerged below its fluid level, effective suction—drainage will be established. In its progress to the pylorus the weighted tip helps the tube to keep its position and direction within the stomach pathway, while it continues suction all the time. On reaching the pylorus this tube will have effectively removed all the stomach contents, the lower openings draining the fluid, the uppermost, the air at the same time (Fig. 5, a, left).

When the tube passes the pylorus and all the lower openings are in the duodenum (as seen by the three-ring mark of 36½ inches from the terminal tip) the duodenal contents begin to be drained. This includes, of course, also the regurgitated fluid from the jejunum. In the diagram the black arrows show the direction of the fluid from the jejunum, while the double arrows show the direction of the drainage fluid within either channel of the tube.

The additional accumulation of fluid and air within the stomach is simultaneously taken in hand by the gastric portion of the tube. Even when the stomach has been entirely emptied, the duodenal side will still continue to drain out both the pancreatic and biliary flow and the regurgitated fluid from the jejunum, the reason being the separate channel allotted to this drainage, independently of the stomach.

THE USE OF THE DOUBLE TUBE IN GASTRO-ENTEROSTOMY

When Levin introduced his nasal tipless catheter tube in 1921, he suggested that before closing the abdomen, the surgeon could pull the tube through the gastro-enterostomy opening and in that way introduce fluids into the duodenum or jejunum after the operation.

Abbott and Rawson (1, 2) in 1937, described another type of tube for use in patients undergoing gastric operations. The purpose was twofold: first, to keep the stomach constantly empty, and, second, to allow jejunal feeding at regular intervals. This was accomplished by the insertion of a silver outlet valve into a regular duodenal tube at the tip for jejunal feeding and of a silver inlet valve, 30 centimeters proximal to the tip, for the aspiration of gastric contents. This one lumen, valved tube was soon abandoned by Abbott and Rawson who found it inadequate and in 1939 they substituted (2) a 2 lumina tube. This tube is 130 centimeters in length, 100 centimeters of which has two lumina, No. 16 French, and is joined by a metal connector to

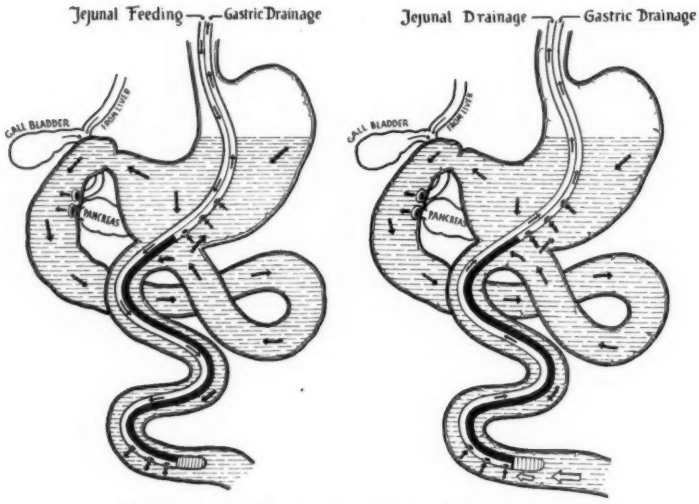

Fig. 6. The use of author's tube in gastro-enterostomy.

a one lumen strip 30 centimeters in length and No. 12 French. Above the metal connector are five openings which represent the gastric side and at the end of the one lumen tube is a metal bucket which represents the jejunal outlet. Markings are placed at a distance of 75 and 85 centimeters from the bucket. The tube is introduced in the following manner: it is passed through the nose, the end is drawn out of the mouth and a metal bucket is attached. The patient is then instructed to swallow the tube to the first mark which is 75 centimeters from the bucket of the tube. When gastro-enterostomy is performed, the surgeon, on completion of the anastomosis, slips the bucket of the tube with his thumb and fingers till it lies 30 centimeters down in the efferent jejunal loop. The tube meanwhile is advanced until the 85 centimeter mark reaches the external nares and is retained in that position. Six hours after operation, nutrient solution may be introduced through one side of the tube which connects with the tip, while through the small openings which lie in the stomach, drainage can be carried out. To remove the tube, the tip must be withdrawn through the mouth, the bucket removed, and the tube then replaced in the mouth and withdrawn through the nose.

The procedure just described is obviously impractical. To overcome these defects, I have modified my double channel tube for possible use in cases of gastro-enterostomy by raising its upper openings to 12 inches from the solid lead impregnated rubber tip, at the same time lengthening the lead shot compartment. The one ring mark is placed at 30 inches and the two ring mark at 37 inches. The tube is inserted through the nose in the ordinary way up to the one ring mark, thus allowing 11 inches to remain in the stomach. On completion of the anastomosis the surgeon slips the terminal end of the tube down into the efferent jejunal loop for a distance of about 14½ inches or until the two ring mark reaches the external nares. In this manner the uppermost opening will lodge in the stomach for gastric drainage while feedings can be supplied to the jejunum through the lower openings (Fig. 6, a, left); a drainage from both stomach and jejunum could be obtained (Fig. 6, b, right). When this tube is ready for removal it can be withdrawn in the ordinary way through the nose.

TECHNIQUE FOR NASAL INTUBATION

The terminal end of the tube, which has previously been dipped in glycerin, is intro-

duced through the nose for a distance of 6 inches, and the patient is then asked to simulate the act of swallowing, while the operator pushes the tube which will be carried down slowly in the esophagus because of its lead weight compartment.

As soon as the first ring mark is reached the patient is turned on the right side. The patient is instructed to swallow the tube very slowly, an inch at a time, over a period of 20 to 25 minutes, until the third ring mark is reached, so that the terminal end will enter the duodenum.

Tests for determining the entrance of the terminal tip into the duodenum. 1. Fluoroscopic and x-ray examinations are of aid in determining the entrance of the tip into the duodenum. Although this method is undoubtedly reliable, yet I believe that it should not be used in routine practice, since in the course of removing the patient to the x-ray room and by manipulation, the terminal portion of the tube may easily slip back into the stomach even with the lead weighted tip.

2. Observation of the differences in color, viscosity, and reaction of specimens obtained from the two outlets: the duodenal specimen will be viscid, golden yellow in color, and negative to Congo red, whereas the gastric specimen will be clearer, perhaps bile-tinged, but positive to Congo red.

3. Injection of a mixture of barium or any other colored solution into the duodenal outlet; no return of dye on the gastric side indicates that the terminal tip has entered the duodenum.

USES

The method has been of use in the following cases:

1. In pre-operative and postoperative gastro-intestinal and abdominal surgery when simultaneous and continuous gastro-intestinal drainage (8) is wanted.

2. In cases in which tubal feeding and drainage are required.

3. In cases of gastro-enterostomy.

4. The use of the tube in medical cases will be presented in a separate paper.

ADVANTAGES

The tube has the following advantages:

1. Effective decompression by means of simultaneous gastroduodenal drainage is offered only through this tube.

2. In gastro-enterostomy cases, jejunal feeding and gastric drainage are easily accomplished without the use of any buckets.

3. The 1½ inch solid lead impregnated rubber tip at the terminal end facilitates introduction and passage of tube through the nares.

4. The weight of the lead-shot compartment together with the lead impregnated rubber tip facilitates the passage of the tube through the esophagus, maintains it in its proper position along the stomach pathway, and aids its entrance into the duodenum.

5. There is less possibility of the lower part of the tube regurgitating into the stomach, as the weight of the lead impregnated solid portion and the lead shot compartment keeps it securely in the duodenum.

I wish to express my gratitude to Mr. L. T. Hilborn, president of Clay-Adams Co., for his kind co-operation in the development of the tube.

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THE OBSTETRIC EXPERIENCES OF WOMEN PARALYZED BY ACUTE ANTERIOR POLIOMYELITIS

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THE primary purpose of our investigation was to determine the effect of paralysis due to acute anterior poliomyelitis on the course of pregnancy and labor. Information was gathered concerning 243 paralyzed women who had had one or more pregnancies subsequent to the onset of the paralysis. We examined 44 of this group of cases personally at the Hospital for Joint Diseases, and we studied the 199 remaining cases through questionnaires which were filled out by the attending obstetricians and orthopedic surgeons and in some instances by the patients themselves. We have been fortunate in obtaining the co-operation of many physicians throughout the United States, and we are indeed grateful to them. The questionnaires are lengthy and comprehensive; copies of them will be found in our original report to the Foundation. Our investigation also afforded us the opportunity of collecting 13 cases in which pregnancy was complicated by an acute attack of anterior poliomyelitis. In addition, we studied the structure of the pelves of 101 paralyzed women, of whom 34 were married and 67 were single, by the Thoms "grid method" of pelviroentgenography. This consists of x-raying the patient's pelvis in a semi-sitting position and then, by the use of a calibrated grid placed in the same plane as that previously held by the pelvic inlet, to superimpose a centimeter calibration on the roentgenogram, thus permitting accurate measurements of the various diameters of the pelvic inlet. Our findings may be grouped under the following three studies: (1) Roentgenographic study of the pelves of women previously paralyzed by acute anterior poliomyelitis; (2) pregnancy complicated by an acute attack of anterior poliomyelitis; (3) pregnancy following previous acute anterior poliomyelitis.

The study was conducted at the Hospital for Joint Diseases, of New York City, aided by a grant approved by The Committee on Research for the Prevention and Treatment of After-Effects of The National Foundation for Infantile Paralysis, Inc.

Read before the American Orthopaedic Association, May 7, 1940.

ROENTGENOGRAPHIC STUDY OF THE PELVES OF WOMEN PREVIOUSLY PARALYZED BY ACUTE ANTERIOR POLIOMYELITIS

Classifications of pelvic types have in the past been based largely upon anatomical specimens. It had become increasingly apparent, however, that such classifications were not of much value in guiding one as to the likely course of labor in a given case. In addition, obstetricians have learned that external measurements of the pelvis yield only an approximate and usually far from accurate estimate of the exact shape and size of the interior of the pelvis. The need for and manifest advantages of an exact knowledge of the structure of the pelvis have led to many studies in roentgenography of the female pelvis and roentgen pelvimetry. These studies have demonstrated that normal pelves differ considerably in their morphology and that depending upon such differences, there are variations in the type of engagement of the presenting part and in the mechanism of labor. The roentgenographic study of the pelvis has been limited by some workers, as Thoms and Jarcho, to an analysis of the pelvic inlet as being sufficient for practical purposes, while others, notably Caldwell and Moloy, have made a more precise study of the pelvic interior through stereoscopic roentgenography.

We roentgenographed 101 paralytic females. There was some degree of asymmetry in 79.21 per cent, while in 20.8 per cent the pelvic inlets were symmetrical (Table I). It is noteworthy that in a study of normal or unparalyzed women, Caldwell, Moloy and D'Esopo found but 4 asymmetrical pelves in 215 primigravidæ. While the incidence of asymmetrical or deformed pelves in infantile

TABLE I.—RELATION OF VARIOUS FACTORS TO ASYMMETRY OF PELVIC INLET
In 101 Unselected Adult Paralytic Females

		Asymmetrical pelves—80 cases, 79.21%	Symmetrical pelves—21 cases, 20.79%
a. Shortening of one lower extremity—90 cases, 89.1% R-43: L-47	Same side as flattening	38	15
	Side opposite flattening	37	
No shortening—11 cases, 10.9%		5	6
b. Pelvifemoral muscle paralysis — 77 cases, 76.3%	Same side as flattening	37	2
	Side opposite flattening	24	
	Bilateral and equal	9	5
No pelvifemoral paralysis—24 cases, 23.7%		10	14
c. Paralysis of muscles below hip—97 cases, 96.2%	Same side as flattening	38	13
	Side opposite flattening	24	
	Bilateral and equal	15	7
No paralysis below hip—4 cases, 3.8%		3	1
d. Axis deviation (rotation) 93 cases, 92.1% R-50: L-43	Toward side of flattening	51	16
	Away from side of flattening	26	
No axis deviation 8 cases, 7.9%		3	5

TABLE II.—RELATION OF VARIOUS FACTORS TO AXIS DEVIATION (ROTATION)
In 101 Unselected Adult Paralytic Females

				Axis deviation 31 cases, 100%		*No Axis deviation*
				right	left	
a. Shortening of lower extremity			Same side	28	29	6
			Opposite side	18	9	R-3 L-3
No shortening				6	3	2
b. Pelvifemoral muscle paralysis			Same side	20	23	2
			Opposite side	12	6	R-1 L-1
			bilateral and equal	6	6	2
No pelvifemoral muscle paralysis				13	7	4
c. Abdominal (anterior and lateral) and quadratus lumborum muscle paralysis			Same side	11		
			Opposite side	3		
			bilateral and equal	6		
No paralysis of abdominal or quadratus lumborum muscles				73		8
d. Relation of lumbosacral rotary-lateral scoliosis	*Group A* (X-ray Study)	Scoliosis present—30 cases, 96.8%	Same side	17	13	
			Opposite side			
		No scoliosis 1 case, 3.2%		1		
	Group B (No X-ray Study)	Scoliosis present	Same side	20	17	
			Opposite side	3	1	
		No scoliosis present		9	12	8

paralysis was very high, we noted that the degree of contraction or flattening of the pelves was generally slight and only exceptionally marked.

In an attempt to determine the forces which were influential in causing such pelvic deformation, we considered the following factors: (1) the effect of associated lumbosacral scoliosis; (2) the rôle of weight-bearing, especially as this factor might be influenced by the use of external appliances and various orthopedic reconstructive operations; (3) shortening of a lower limb; (4) muscle imbalance due especially to paralysis of the pelvifemoral and pelvispinal muscles; and (5) paralysis of the muscles below the hip.

1. *The effect of associated lumbosacral scoliosis* (*Tables I and II*). It has long been known that fixed lateral curvature of the spine is invariably associated with rotation of the vertebral segments toward the convex side, and that in the dorsal region the ribs become deformed in such a way that there is flattening of the chest on the side of the convexity, anteriorly, and on the side of the concavity, posteriorly. We have anticipated that a like mechanism might be operative in the pelvis, by considering the innominate bones as representing the costal cage, the sacro-iliac joints as representing the costovertebral joints, and the symphysis pubis as equivalent to the sternocostal articulations. With a scoliosis involving the lumbar spine and sacrum, and with rotation toward the convexity, one should, therefore, anticipate the following deformity of the pelvic ring—flattening anteriorly on the side of the convexity of the lumbosacral curve, and flattening posteriorly on the side of the concavity (Fig. 1). The effect on the costal cage by the rhythmic alterations of intrathoracic pressure consequent upon cardiovascular and respiratory functions is duplicated by the changes in the

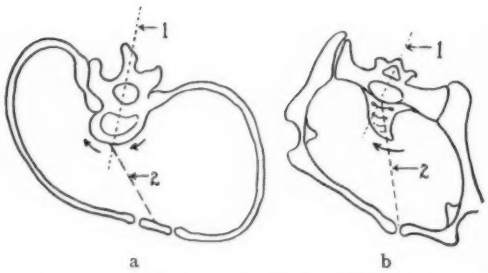

Fig. 1. a, Deformity of the costal cage secondary to rotary-lateral scoliosis in the dorsal spine. There is flattening anteriorly on the side of the convexity of the dorsal scoliosis and flattening posteriorly on the side of the concavity. *1*, Sagittal axis of the thoracic vertebrae indicating rotation to the right; *2*, anteroposterior axis of the costal cage. b, Deformity of the pelvic ring secondary to rotary-lateral scoliosis in the lumbosacral spine. There is flattening of the pelvic ring anteriorly on the side of the convexity and flattening posteriorly on the side of the concavity of the lumbosacral scoliosis. *1*, Sagittal axis of the sacrum indicating rotation to the right; *2*, anteroposterior axis of the pelvic inlet.

pelvic frame arising from the intra-abdominal pressure changes secondary to diaphragmatic movements and cardiovascular function. In 30 roentgenographically proved cases of lumbosacral scoliosis in this group, there was in every instance the anticipated distortion and asymmetry of the pelvis (Table II). It may here be emphasized that the *clinical judgment* as to the presence, type and extent of a scoliosis, especially in the lumbosacral region cannot alone be relied upon and that a *roentgenogram of the spine* is essential for accuracy.

The anteroposterior axis of the pelvic inlet extends between the symphysis pubis and the sacral promontory. A shift of the sacral promontory to the right or left necessarily implies a shift or rotation of the anteroposterior axis of the pelvis. We found that in 93 of the 101 pelvic inlets there was deviation of the anteroposterior axis posteriorly, to the right or to the left of the sagittal plane. In 51 cases there was asymmetry of the pelvis due to flattening anteriorly, on the side corresponding to the posterior shift of the anteroposterior axis rotation (Fig. 3). In 16 cases with axis rotation, there was no asymmetry of the pelvis. Possibly, the explanation of the absence of asymmetry in this group of 16 cases lies in the fact that not enough time had elapsed to permit the change in the pelvic ring. In 26 cases there was asymmetry of the pelvis but the flattening was on the opposite side (Table I). It is difficult to explain the opposite sides of the axis deviation and flattening of the pelvis in these 26 cases unless it be that the flattening occurred on the same side as the original scoliosis, but that with the subsequent development of a lower compensatory curve the side of the axis deviation and the flattening have become oppositely placed. However, in most of the cases there is apparently a definite relation between the rotation in the lumbosacral region arising from a lumbosacral scoliosis, primary or secondary, and the asymmetrical flattening of the pelvic ring (Fig. 3).

This relationship between lumbosacral scoliosis and asymmetry of the pelvis was further confirmed by roentgenography of the pelvic inlets of 4 cases of *idiopathic* scoliosis with lumbosacral curves, selected from a series of approximately 24 cases of *idiopathic* scoliosis. In these cases also, the pelvic inlet was flattened anteriorly on the side of the convexity and posteriorly on the side of the concavity of the lumbosacral rotary-lateral scoliosis.

2. The effect of weight-bearing on pelvic asymmetry. Our studies lead us to believe that when weight is unequally distributed on the two sides of the pelvis, the side on which there is greater weight and pressure will become flattened. In bedridden patients we find large symmetrical pelves. Similarly, in those patients who walk with the aid of crutches and bear little or no weight on their legs, the pelves remain large and fairly symmetrical (Figs. 4a and 4b). In 8 cases of paralytic dislocation of the hip, we noted flattening of the pelvic inlet anteriorly on the side opposite the dislocation, that is, on the normal or less paralyzed side. Due to the dislocation, the direct thrust of weight-bearing was brought to bear almost entirely on the side where no dislocation was present (Fig. 5). An additional experience was afforded in 3 cases with unilateral congenital dislocation of the hip in which there was paralysis following acute anterior poliomyelitis. In 2 cases flattening of the pelvic inlet occurred anteriorly

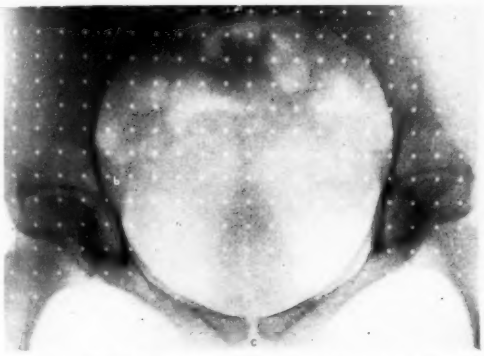

Fig. 2. Pelvic inlet of a normal married female, nullipara, aged 27 years. There is perfect symmetry of both halves of the pelvis and of the pelvic inlet outline. *a*, sacral promontory; *b*, ischial spine; *c*, symphysis pubis. The anteroposterior diameter of the pelvic inlet equals 12.25 centimeters, transverse diameter equals 12.35 centimeters. Morphological classification of the type of pelvis: gynecoid type (Caldwell–Moloy); average, round type (Thoms).

on the side of the intact hip joint, although the extremity on this side was severely paralyzed (Fig. 6). In the third case, the paralysis was present on the same side as the congenitally dislocated hip. Flattening occurred on this side because the lesser trochanter abutted satisfactorily upon the acetabulum, permitting stable weight bearing (Fig. 7). Thus, we conclude that weight-bearing is an important factor in poliomyelitis in causing or contributing toward flattening

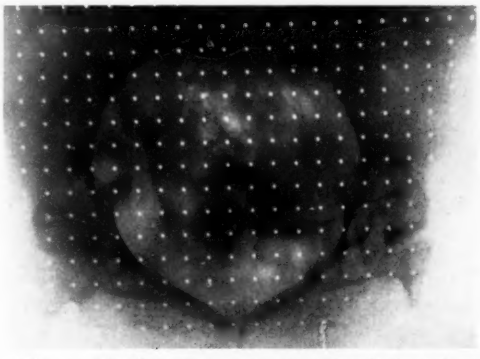

Fig. 4a. This figure shows the effect of scoliosis without weight-bearing. This is a case in which there was no weight-bearing, the patient bearing most of her weight on her upper torso by means of two crutches. Photograph illustrates a large pelvic inlet with slight flattening of the right pelvis, anteriorly, and slight anteroposterior axis rotation to the right, posteriorly. *a*, Sacral promontory; *c*, symphysis pubis. Arrow marks slight flattening of the pelvic inlet on the right side anteriorly. This patient is 20 years old, single and has been paralyzed for 10 years. There is severe involvement of both lower extremities which are flail, but there is no shortening. There is a right lumbar, right lumbosacral scoliosis. X-ray measurements: anteroposterior, 11.65 centimeters, transverse, 11.75 centimeters.

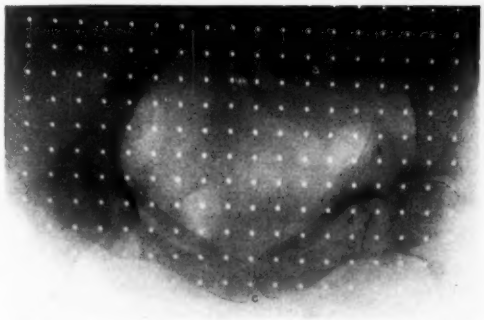

Fig. 3. There is flattening of the pelvis anteriorly on both sides, more marked on the left, secondary to a left lumbar, left lumbosacral scoliosis. There is anteroposterior axis rotation of the pelvic inlet to the left posteriorly. *a*, Sacral promontory; *b*, ischial spine; *c*, symphysis pubis; *d*, obturator foramen. This patient is 24 years old, single and has been paralyzed for 23 years. There is complete paralysis of both lower extremities without shortening. She wears two long leg braces and utilizes no crutches. X-ray measurements: anteroposterior, 7.75 centimeters, transverse, 11.25 centimeters.

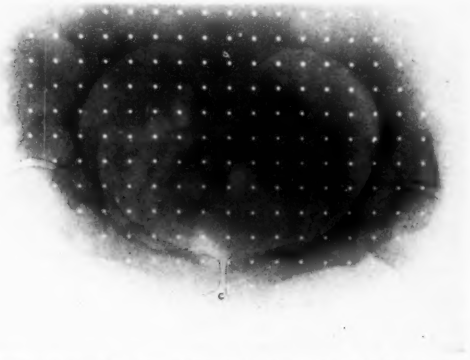

Fig. 4b. This figure shows the effect of weight-bearing without scoliosis. In this case there was symmetrical flattening of both sides of the pelvis, anteriorly, with shortening of the anteroposterior diameter of the pelvic inlet and without axis rotation. *a*, Sacral promontory; *c*, symphysis pubis. This deformity was secondary to weight-bearing by means of two long leg braces without the aid of crutches, both lower extremities being flail. There was no shortening or scoliosis. X-ray measurements: anteroposterior, 7.30 centimeters; transverse, 12 centimeters.

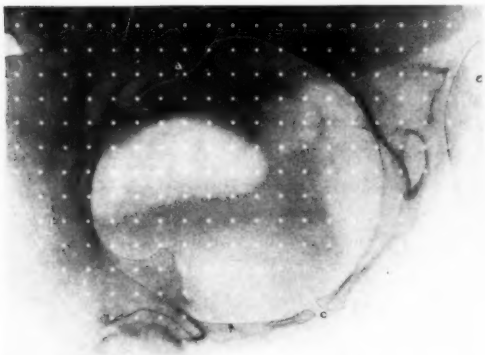

Fig. 5. This illustrates slight flattening of the right side of the pelvis, anteriorly, associated with complete paralytic dislocation of the left femoral head. There is a severe anteroposterior axis rotation to the right, posteriorly. It will be noted in this case that there is greater density of the bones comprising the right hip as compared to the left. *a*, Sacral promontory; *c*, symphysis pubis; *e*, complete paralytic dislocation of left hip. Arrow marks flattening of the pelvic inlet on the right side anteriorly. This patient is 16½ years old, single, and has been paralyzed for 11½ years. There is severe paralysis of both lower extremities and paralysis of the right abdominal muscles. The right lower extremity is shorter than the left by 1 inch and there is a left dorsal, right dorsolumbar scoliosis. She utilizes two long leg braces and two crutches. Operation: right abdominal fascial transplant. X-ray measurements: anteroposterior, 12.15 centimeters; transverse, 12.15 centimeters.

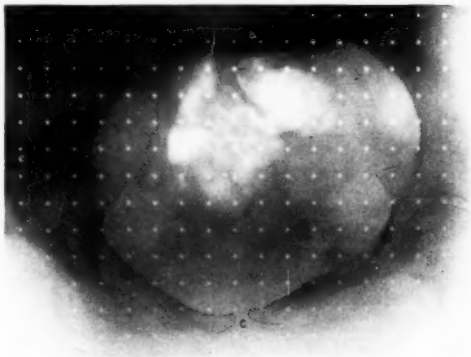

Fig. 6. This illustrates flattening of the left pelvis, anteriorly, associated with a left lumbar scoliosis and with a complete *congenital* dislocation of the right femoral head (untreated). The anteroposterior axis of the pelvic inlet is rotated to the left, posteriorly. *a*, Sacral promontory; *c*, symphysis pubis; *e*, congenital dislocation of the right hip. Arrow marks flattening of the pelvic inlet on the left side anteriorly. This patient is 28 years old, married, and has had three children. She has been paralyzed for 22½ years, there being total paralysis with 2 inches shortening of the left lower extremity. She wears a long left leg brace. X-ray measurements: anteroposterior, 9.65 centimeters, transverse, 12.15 centimeters.

of the pelvis and asymmetry of the pelvic inlet.

3, 4, and 5. Effect of shortening of a lower limb, pelvifemoral muscle paralysis and paralysis of the muscles below the hip (Table I). The side of shortening, varying from ¼ to 4½ inches with an average of 1.45 inches, corresponded to the side of anterior flattening of the pelvic inlet in only 38 of the 101 cases. The side of pelvifemoral muscle paralysis (or the side of greater involvement, when bilateral) corresponded to the side of flattening of the pelvic inlet, anteriorly, in only 37 cases. The side of paralysis of the muscles below the hip (or the side of greater involvement, when bilateral) corresponded to the side of the pelvic flattening, anteriorly, in only 38 of our cases.

It is our belief, therefore, that these factors are not directly influential in the etiology of asymmetry of the pelvis, but that they are influential indirectly where they may initiate or exaggerate a lumbosacral scoliosis.

We wish also to note a type of deformity of the entire pelvis hitherto not emphasized in paralytic patients. Considerable attention has been given to lateral pelvic obliquity consequent upon abdominal paralysis or due to pelvifemoral (abduction-adduction) muscle imbalance. We have pointed out that rotation of the entire pelvis as a unit can occur about its longitudinal axis. It is well known that the pelvis can tilt anteriorly about a transverse axis resulting in increased lumbar lordosis. In 7 of our cases it was noticed that the anterosuperior iliac spine of one innominate bone was lower and more anterior than the opposite one, while disparity between the level of the iliac crests was either not present or present to a lesser extent. This appears explicable on the assumption that there was rotation of the innominate bones on a transverse axis, but that one innominate bone rotated through a greater arc than the other resulting in a "torsional deformity."

From our roentgen examination of the pelves in 101 paralyzed women, we have concluded that asymmetry of the pelvic inlet is an unusually common occurrence. Practically

80 per cent show some degree of pelvic distortion. Fortunately, the deformity is usually of a mild degree so that it is not likely to cause dystocia. There are probably many factors associated in causing the pelvic asymmetry. We believe that the chief one is anteroposterior axis deviation of the pelvis about its longitudinal axis. Other factors, especially weight-bearing which is dependent to a great extent upon whether the patient has been rehabilitated by the use of external appliances or reconstructive orthopedic operations or both, also play significant rôles. It is our belief that rotation of the anteroposterior axis of the pelvic inlet is invariably dependent upon rotation in the lumbo-sacral spine consequent upon a scoliotic deformity.

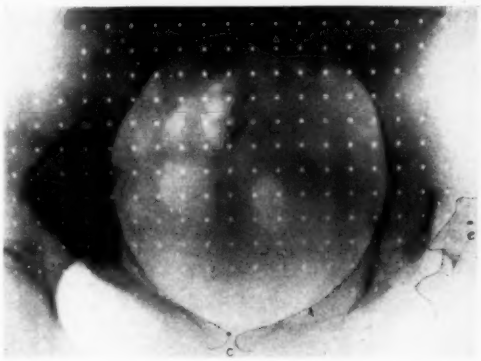

Fig. 7. This illustrates flattening of the left pelvis, anteriorly, secondary to a left lumbar, left lumbosacral scoliosis. There is a congenital dislocation of the left femoral head, which although untreated is very stable because the lesser trochanter abuts within the acetabular fossa. For this reason this case differs from those illustrated in Figures 5 and 6, in that the side of dislocation and flattening of the pelvis anteriorly correspond. There is anteroposterior axis rotation to the left posteriorly. *a*, Sacral promontory; *c*, symphysis pubis; *e*, congenital subluxation of the left hip with the lesser trochanter abutting against the acetabulum. Arrow marks flattening of the pelvic inlet on the *left* side anteriorly. This patient is 23 years old, single, and has been paralyzed for 22 years. There is paralysis involving the left lower extremity with shortening of 2 inches despite a leg lengthening of 2 inches performed 6 years ago. X-ray measurements: anteroposterior, 12 centimeters, transverse, 11.25 centimeters.

PREGNANCY COMPLICATED BY AN ACUTE ATTACK OF ANTERIOR POLIOMYELITIS

One might anticipate that such a complication would constitute a great hazard to both mother and fetus. One may also appreciate that since no one of us has had any considerable experience with this unusual combination, the attending physicians might be at a loss to know how to direct their therapeutic energies. The literature reveals that 15 such cases have been reported wherein an acute attack of anterior poliomyelitis occurred during a pregnancy. We were fortunate to collect 13 additional cases and an analysis of this group of patients serves to help us to formulate an adequate program of treatment.

Single cases have been reported by Schell, 1906; Renault and Martingay, 1911; Zimmerman, 1914; Hornung and Creutzfeldt, 1930; Ruhl, 1939; and Morrow and Luria, 1939. Miller (8) in 1924 reported 2 cases; McGoogan, 1932, 3 cases, and Brahdy and Lenarsky, 1933, 3 cases. Ruhl refers to 1 case reported in the literature, the recorder of which is uncertain. Newberger and his associates have communicated to us the details of 1 additional case which they intend to report. In these 16 cases the paralysis was extensive in many; in fact it was of the ascending type with respiratory involvement in 4. The stage of pregnancy varied from 1½ to 9 months, and the ages of the patients from 19 to 32 years. Normal spontaneous deliveries occurred in 10, forceps were applied to the presenting part after it reached the pelvic floor in 2, and there was a breech extraction in 1. There was a cesarean section in 2 instances, 1 at 6 months and the other at term. A therapeutic abortion was employed in 1 instance, but without a definite indication. It is noteworthy that this patient, although still severely paralyzed, since has had a normal pregnancy and labor. A normal child was born in *12 instances* and a live child with bilateral clubfoot in one instance. Of the 2 premature offspring, one was dead at birth, while the other survived only 48 hours. None of the newborn and the 2 dead fetuses gave no evidence of having had paralysis.

We ourselves have been fortunate in collecting from various obstetricians and orthopedic surgeons a series of 13 hitherto unreported cases. The experiences in this series are similar to those previously reported. Paralysis was quite extensive in many instances. The stage of pregnancy varied from 1.5 to 7

TABLE III.—ORTHOPEDIC STATUS IN 209 CASES (GROUPS A—B*)

	No. of cases	Incidence percentage 209 cases
Extent of paralysis		
One or both lower extremities	134	59.33
One or both upper and lower extremity	6	2.87
One or both upper extremities	5	2.39
Abdomen or back muscles	5	2.39
Abdomen, back and extremities	25	11.96
Inadequate data	44	21.06
Deformities		
None	46	22.01
Deformities of trunk and/or extremities	140	66.98
Inadequate data	23	11.01
External appliances		
None	135	64.57
Brace, corset and/or crutches	69	33.01
Inadequate data	5	2.40
Orthopedic operations		
None	84	40.19
Stabilizations, tendon transplants and/or correction deformities	96	45.03
Inadequate data	29	14.78

*{Group A—cases delivered with ease. Group B—cases delivered with difficulty.

TABLE IV.—AGE, DURATION OF POLIOMYELITIS, NUMBER OF YEARS MARRIED, NUMBER OF PREGNANCIES AND DELIVERIES (GROUPS A AND B)

Present age (209 cases)		Duration of poliomyelitis prior to first pregnancy (201* cases)		Number of years married prior to first pregnancy (201* cases)	
Age (years)	No. of cases	No. of years	No. of cases	No. of years	No. of cases
10–15	1	6–11 mos.	1	1	56, 27.9%
16–20	17	1– 5 yrs.	10	1.5	1
21–25	42	6–10	13	2	21
26–30	64, 30.6%	11–15	37	2.5	2
31–35	43	16–20	53, 26.4%	3	14
36–40	16	21–25	52, 25.9%	3.5	1
41 plus	14	26–30	17	4	3
Unknown	12	31–35	5	5	4
		36–40	2	7–15	4
		Unknown	11	Unknown	81
youngest —13 years					
oldest —59 years				Unmarried	14
average —29.2 years					

Number of pregnancies (209 cases)			Number of deliveries (201* cases)		
No. of pregnancies per case	No. of cases	Total No. of pregnancies	No. of deliveries per case	No. of cases	Total No. of deliveries
1	106, 50.7%	106	1	115, 57.2%	115
2	55, 26.8%	110	2	50, 24.9%	100
3	31, 14.0%	93	3	21, 10.4%	63
4	6	24	4	7	28
5	4	20	5	3	15
7	3	21	7	2	14
8	1	8	8	1	8
9	2	18	9	2	18
10	1	10		201	361
	209	410			
Minimum number of pregnancies per case 1			Minimum number of deliveries per case 1		
Maximum number of pregnancies per case 10			Maximum number of deliveries per case 9		
			Number of abortions 35		

Group A—cases delivered with ease.
Group B—cases delivered with difficulty.
*Excluding 8 cases who were pregnant at time when analysis was completed, 7 of whom were primipara, and 1 a secundigravida who had previously miscarried.

months. The age of the mothers varied from 17 to 28 years. There were normal spontaneous deliveries in 5 cases, a breech extraction in 1 case, while in 4 instances forceps were employed after the head had spontaneously descended to the pelvic floor. There were 2 difficult mid-forceps deliveries with birth of normal children. A spontaneous miscarriage occurred in 1 instance, 1 week after the acute attack. A normal child was obtained in the 12 patients who delivered at term.

From the preceding résumé it becomes apparent that, notwithstanding severe paralysis involving the abdominal and extremity muscles and occurring during gestation, a normal course of pregnancy and labor and a normal offspring may be anticipated. The reason for this is premised not only upon the clinical facts as obtained in the cases here noted, but also upon experimental evidence. Physiologists have demonstrated that the uterus will contract after division, not only of the spinal cord but also of its sympathetic nerve supply, proving that the uterus has an independent nerve supply within its own substance which is not disturbed by anterior poliomyelitis. A like experience has been noted in patients paralyzed following cord tumor, spondylitis, and vertebral fracture. It is true that after the presenting part has

descended spontaneously to the pelvic floor the absence of adjutant voluntary powers may necessitate the employment of some mechanical maneuver, such as manual extraction or forceps, to effect completely the delivery, but this does not constitute a danger to either the mother or child.

The appearance of acute anterior poliomyelitis during pregnancy, therefore, need not cause undue alarm. Except in the rare instances of bulbar or ascending paralysis, there will not be a fatal issue but rather progressive improvement or recession of the paralysis after the usually short acute stage has passed. One should not contemplate a therapeutic abortion as the senior author advised several years ago from sheer ignorance. The pregnancy will most likely go to term, and the labor be entirely uncomplicated. Nor need we anticipate that the paralysis will be more severe than usual because of the pregnancy. Both conditions, the pregnancy and the paralysis, will follow uninfluenced courses in the majority of cases.

It is interesting to note that there has been no instance of intra-uterine poliomyelitis. The work of immunologists has indicated that there is a transmission of absolute passive immunity from the mother to the offspring. Unfortunately, this does not persist, for a number of instances of acute anterior poliomyelitis in children under the age of one month have been reported.

PREGNANCY FOLLOWING PREVIOUS ACUTE ANTERIOR POLIOMYELITIS

In this part of our study, we analyzed the data relative to 243 patients who had been paralyzed by previous acute anterior poliomyelitis for 1 year or more prior to pregnancy. The analysis was conducted by dividing the cases into 3 groups. Group A included those in whom deliveries were spontaneous or effected easily; group B those in whom deliveries were effected with difficulty. There were 201 cases in groups A and B, excluding 8 patients who were pregnant at the time that the analysis was completed, 7 of whom were primiparæ and 1 a secundigravida who had previously miscarried. The third group, X, included 34 cases for whom the data were relatively inadequate. The incidence of paralysis, the incidence of deformity and the frequency of employment of orthopedic reconstructive procedures were all greater in group B in which there was greater difficulty in labor than in group A (Table III). In 28 cases in whom the pelvis was studied both roentgenographically and by external pelvimetry, we were impressed by a fact that has been stressed by many workers, namely, that the external and internal pelvic measurements alone are less accurate than roentgenographic pelvic measurements in determining the pelvic adequacy for parturition. In these 28 cases, roent-

TABLE V.—COMPLICATIONS IN MOTHER (209 CASES) AND OFFSPRING (361 CASES)—GROUPS A—B

Complications		No. of cases
a. *During pregnancy*		
1. Abortion	35	
a. Therapeutic	8	
b. Spontaneous	22	
c. Self-induced	5	20, 9.5%
2. Toxemia of Pregnancy		
a. Nausea and vomiting	7	
b. Hypertension and albuminuria	12	
c. Nephritis	1	
d. Eclampsia	2	22, 10.53%
3. Hypertension		6
4. Cardiac disease and decompensation		3
5. Pyelitis, toxic thyroid, uterine fibroid, placenta previa, premature separation of placenta, ruptured uterus, diabetes mellitus, secondary anemia		1 each
b. *Following pregnancy (in mother)*		
1. Postpartum hemorrhage		4
2. Pyelitis		3
3. Phlebitis		3
4. Cardiac decompensation		3
5. Nephritis		2
6. Shock, uterine sepsis, adherent placenta, pulmonary tuberculosis and acute yellow atrophy of liver, death following eclampsia, varicose veins of leg, cystocele and rectocele, toxic goitre, renal calculus		1 each
c. *In offspring*		
1. Death		
a. Prolapsed cord	2	
b. Cerebral hemorrhage	2	
c. Monster	1	
d. Pneumonia	1	
e. Cause unknown	16	22, 5.4%
2. Convulsions, anemia of newborn, hydrocele, bilateral undescended testicle, facial paralysis (instrumental), bilateral club-foot, unilateral club-foot		1 each

Group A—cases delivered with ease.
Group B—cases delivered with difficulty.

TABLE VI.—DATA RELATIVE TO GESTATION

Duration of labor in 361 deliveries (groups A and B) (201* paralytic females)		Average No. of hours in *non-paralytic* females (Stander)	Type of presentation in 361 deliveries (groups A–B) (201* paralytic females)			Incidence percentage in 75,000 deliveries at Johns Hopkins Hosp. (Stander)
No. of hours	No. of cases		Presentation	No. of cases	Incidence % in 361 deliveries	
No test of labor	27		Vertex	306	84.76	94.6
Less than 1 hour	5					
1 to 5 hours	74		Breech	12	3.32	3.9
6 to 10 hours	60					
11 to 15 hours	32		Transverse	2	.55	0.96
16 to 20 hours	13					
21 to 25 hours	6		Face	1	.27	0.34
26 to 30 hours	3					
31 to 40 hours	4		Inadequate			
41 to 55 hours	7		data	40	11.10	
72 to 76 hours	5					
Inadequate data	125					
minimum no. hours	1					
maximum no. hours	76					
Average no. hours primipara	15.06	18				
multipara	9.06	12				

TYPE OF DELIVERY

In 407 deliveries (235* cases in groups A, B and X)

Type of delivery	No. of deliveries	Incidence % in 407 deliveries	Percentage incidence of cesarean section in *non-paralytic* females
Normal (spontaneous with or without anesthesia)	264	64.86	
Forceps	85	20.88	0.92 (Williams); 2.07 (Miller); 0.78 (Mosher); 0.11–1.51 (Tottenham quoted by Mosher)
Cesarean section	47	11.54	
Breech extraction	2	.49	
Internal podalic version	2	.49	
Inadequate data	7	1.74	

Group A—cases delivered with ease.
Group B—cases delivered with difficulty.
*Excluding 8 cases who were pregnant at time when analysis was completed, 7 of whom were primipara, and 1 a secundigravida who had previously miscarried.

genographed by the Thoms grid method, there was oblique contraction of the pelvic inlet in 75 per cent, while in 25 per cent the inlet was symmetrical. The average measurements of the pelvis in these cases compared favorably with the averages given by Jarcho for 200 normal females.

The number of pregnancies in the entire series varied from a minimum of 1 to a maximum of 10, and the number of deliveries from a minimum of 1 to a maximum of 9. Fifty per cent of the patients were pregnant at least once, the remainder delivering two or more times. In 209 cases there were 410 pregnancies, while in 201 cases there were 361 deliveries, excluding 35 abortions (Table IV). Fourteen patients were still pregnant at the time that this analysis was completed. Complications such as abortions, 9.56 per cent, toxemia of pregnancy, 10.53 per cent, and postpartum hemorrhage, pyelitis, phlebitis, nephritis, uterine sepsis, cardiac decompensation and adherent placenta occurred in *percentages almost identical* to the statistical reports of such complications in *non-paralytic females* (Table V).

The duration of labor varied from 1 to 76 hours. The average number of hours of labor in the primiparous women was 10.05 hours, and in the multiparous patients was 9.06 hours (Table VI). Of 361 deliveries in groups A and B, 84.76 per cent were vertex, 3.32 per cent were breech, 0.55 per cent were transverse, 0.27 per cent were face, while data were inadequate in 11.1 per cent. Sixty-five per cent were delivered normally or spontaneously with or without an anesthetic, 21.0 per cent by forceps, 11.54 per cent by cesarean section and the 4 remaining cases by breech extraction and internal podalic version. It is difficult to compare the incidence of the utilization of forceps in non-paralytic females and paralytic females, because of the tendency in different clinics to utilize elective forceps in a variable percentage of cases. Forty-seven cesarean sections were performed in our series of 407 deliveries, an incidence of 11.54 per cent, which is very high as compared to the frequency of utilization of this procedure in non-paralytic cases. We believe, however, that there are many factors which have served to create this high percentage and that this figure does not indicate this procedure to be more frequently necessary in effecting delivery in paralytic females. For example, there were 11 cases in which cesarean section was definite-

TABLE VII.—INDICATION FOR CESAREAN SECTION

		No. of cases having cesarean sections	Indications for cesarean section in non-paralytic females (percentage incidence)	
Total—47 cesarean sections in		38	(Williams quoted by Stander)	444 cesarean sections
a. Definite indications Dystocia	1. Causes possibly related to poliomyelitis—Contracted and deformed pelves. Abdominal weakness in only 1 case	4	Contracted pelves 72.80 Toxemia of pregnancy 7.45	Disproportion 37.4 Eclampsia. Toxemia of pregnancy 27.0
Test of labor	2. Causes not related to poliomyelitis—Large fetal head, premature separation of placenta, obstruction by nongravid horn of bicornuate uterus, cardiac decompensation, rigid cervix, uterine inertia, transverse arrest, midpelvic impaction, etc.	7	*Other factors* 19.75 Premature separation of placenta Placenta previa Tumors Heart disease Elderly primipara, etc.	*Other factors* 17.4 Tumors Phlebitis Heart disease Myelitis Incomplete rupture uterus Elderly primipara, etc.
b. Questionable indications No Test of Labor	1. "Small pelvic measurements" according to obstetrician. No x-ray study and measurements. No other pregnancies	16		
	2. For sterilization purposes	3		For sterilization 3.7
	3. No reason given. Other pregnancies in these cases were normal (spontaneous) or by forceps	4		Because of previous cesarean section 18.7
	4. Toxemia of pregnancy	1		Placenta previa 8.3
	5. Other reasons—example, "obstetrician felt better," etc.	3		Premature separation of placenta 1.3

ly required, but of these only 4 had indications possibly related to the poliomyelitis. These 4 patients had contracted and deformed pelves with a disproportion between the fetal head and the maternal pelvis and a failure of progression after a test of labor. The indications in the 7 other cases were definitely nonpoliomyelitic factors (Table VII, a). In the 27 remaining cases, the indications were less definite. In some instances the obstetrician was guided by clinical pelvic measurements as indicative of cephalopelvic disproportion without the benefit of a roentgenographic study. In others the indication was surgical sterilization, even though in many instances previous pregnancies had been effected normally or by forceps (Table VII, b). It becomes difficult, therefore, to evaluate this factor except to conclude that the figure of 11.54, representing the incidence percentage of cesarean section in our analysis, is probably an exaggerated estimate of the exact indication of this procedure in paralytic females.

Three hundred and sixty-one children were delivered to 201 paralytic females in groups A and B. The complications that occurred in the children during or shortly after birth were no different and no more frequent than those in children born of non-paralytic females (Table V, c). There were bilateral clubfoot and unilateral clubfoot deformities in 1 case each, but there was no other evidence of paralysis in these children. Facial paralysis in 1 instance was probably due to a difficult forceps delivery. There was no evidence of intra-uterine transmission of poliomyelitis to the offspring in any of our cases.

Of special interest to us, as orthopedic surgeons, is the fact that none of the reconstructive orthopedic procedures employed to rehabilitate these patients exerted any adverse effect on the course of delivery. There were spine fusions performed in 6 patients, and even though in some instances this included the lumbosacral area, the course of labor was not affected. In 1 patient with a surgically fused hip and a secondary 15 degree adduction deformity, there was a spontaneous delivery with the patient in the Sims position. There was no instance in which the patient had had a previous abdominal fascial transplant. Dr. Charles Leroy Lowman has written us that in his 1 patient who had become pregnant subsequent to an abdominal fascial transplant, no difficulty was encountered, and that at the present time the transplants are apparently working satisfactorily.

It becomes apparent, therefore, that not only in acute cases but also in the patients paralyzed for long periods, a normal course of

gestation and labor may be anticipated in the absence of complications. The incidence and type of complications of pregnancy are practically the same in paralytic and non-paralytic females, except perhaps in the use of cesarean section. We believe that the high incidence of cesarean section found in our study was due to the improper selection of the procedure in many of the instances. The termination of the delivery in paralytic women may have to be assisted by some maneuver, such as manual extraction or forceps. This can hardly be called a complication since it is frequently employed in the final stage of labor for nonparalytic women and causes no appreciable damage to maternal or fetal tissues. There has been no evidence of intra-uterine transmission of poliomyelitis from the mother to the offspring in our series.

CONCLUSIONS

Our study of the obstetric experiences of paralyzed women leads us to the following conclusions.

1. Asymmetry of the pelvic inlet is found in approximately 80 per cent of the pelves of women who have had infantile paralysis. The distortion is mild in the majority of cases so that it does not produce dystocia. Asymmetry of the pelvis is absent in those who, because of extensive paralysis are either completely bedridden, never having attempted to bear weight on either lower limb or get about with braces and crutches, bearing most of the weight on the arms. The pelvic asymmetry is undoubtedly due to a combination of factors, one of the most important of which is rotation of the pelvic ring consequent upon and secondary to a lumbosacral rotary-lateral scoliosis. Weight-bearing is also instrumental in the causation of deformity of the pelvic ring. This factor is dependent upon: (a) the degree of rehabilitation of the patient by the use of external appliances or orthopedic reconstructive procedures or both, and (b) the degree of atrophy and underdevelopment of the associated bony pelvis. Other factors, such as shortening of a lower limb and muscle imbalance, are instrumental, especially where they initiate or exaggerate a lumbosacral scoliosis.

Attention has been called to 4 types of deformity of the pelvis as a whole: (1) lateral pelvic obliquity, (2) increased anterior pelvic tilt with exaggerated lumbar lordosis, (3) anteroposterior axis deviation or rotation about a longitudinal axis, and (4) rotation of one innominate bone upon the other innominate bone about a transverse axis, or torsional deformity.

2. From an analysis of 15 cases reported in the literature, 1 case communicated to us, and 13 cases collected by ourselves, we conclude that pregnancy complicated by acute anterior poliomyelitis may be anticipated to progress normally, with a normal termination of labor and with a normal offspring. The involuntary contractions of the uterus and the ability of the uterus to expel its contents spontaneously observed also in patients paralyzed by cord tumors, spondylitis, and vertebral fracture are due to the fact known to physiologists, that the uterus has an independent nerve supply and will contract not only after the spinal cord is transected but even after its sympathetic nerve supply is extirpated. There was no instance of intra-uterine poliomyelitis in these 29 cases. The passive immunity of the offspring derived from the mother does not persist for long, since a number of cases of acute anterior poliomyelitis under the age of 1 month (earliest, 9 days) have been reported.

3. An analysis of 243 patients, who became pregnant one year or more subsequent to an acute attack of anterior poliomyelitis, indicates that a normal and uneventful pregnancy and labor with a normal offspring may be anticipated in these cases. There is no indication for interruption of the pregnancy at any stage, except for those reasons that would be operative also in non-paralytic females. The complications prior to and following delivery in paralytic females are, on the percentage basis, almost identical with those in non-paralytic females. Although it is true that in our analysis of paralytic females, cesarean section was utilized in a higher percentage of cases than in a comparable series of non-paralytic females, it is our belief that the indications for this procedure in some instances may not have been warranted, and that, therefore, this percentage probably does

not represent the true index of the need of this procedure in paralytic females.

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LIVER CELL FAT NECROSIS CAUSED BY PANCREATIC REFLUX

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DURING the past 20 years, in addition to the investigation of specific changes in the liver itself, research has been made along two lines concerning the relationship of the liver to other organs. Functionally, in so far as the metabolism of hemoglobin and its derivatives, the bile pigments, is concerned, the liver is closely related to the spleen. Surgically, the close topographical relation of the liver and the pancreas is very important, especially when disease of the gall bladder and pancreas is being treated. However, the pathological problems arising within the hepatopancreatic system are due not only to their close proximity, their close connection of blood and lymph supply but also to the proximity of the two excretory ducts in the papilla of Vater. The mechanism which transforms the two outlets, that of the liver and that of the pancreas, into one communicating system of channels lies in the occlusion of the common outlet for both in the papilla of Vater. The diverticulum thus becomes transformed into a sort of pot in which the two secretions are mixed. The difference between hepatic and pancreatic secretory pressures determines into which duct the mixture is forced. The relatively high incidence of anatomical variations in the mutual position of the ducts and their openings reduces the probability of the reflux; for instance, when the pancreatic duct opens outside of the diverticulum, the occlusion of the papilla has no influence on the pancreas. Three main types of occlusion may occur as the result of stones, spasm, or edema of the duodenal mucous membranes. The most important cause is stones. Since Opie and Halsted published their classical papers, numerous other cases have been observed and reported by various authors (Truhart, Korte, Schottmueller, Schmieden and Schering and, particularly, Cameron and Noble). In some of these cases congestion, the result of retention of pancreatic secretion, with its subsequent hemorrhagic pancreatic necrosis, was the only observation made.

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It has been safely established that occlusion of the papilla by any mechanism may cause passive congestion in the pancreatic ducts by back pressure of the pancreatic juice and that this congestion may be followed by rupture and bursting of the duct walls and imbibition by the pancreatic tissue of the oozing pancreatic secretion. In this manner is produced the well known pathology of pancreatic necrosis and later intraperitoneal fat necrosis. This process has been thoroughly investigated particularly by Opie, Balo and Ballon, Westphal, Archibald, and many others. The importance of retention of pancreatic secretion as an etiological factor in acute pancreatic necrosis is well established, in spite of the fact that, as is well known to pathologists, at autopsy in cases of acute pancreatic necrosis the hemorrhagic destruction of the gland makes it generally impossible to find the spot where the rupture of the duct occurred. It is much more difficult, however, to give accurate proof or evidence of the reflux. Here we must distinguish between two possibilities: first, bile flowing in the pancreatic ducts, and, second, pancreatic secretion flowing in the bile duct.

From clinical and pathological observation, there is better and more convincing evidence for a reflux from the liver to the pancreas. Colp and his collaborators made this reflux visible by x-ray in patients with gall-bladder drains, after the injection of morphine to produce a spasm of the sphincter of the papilla. They explain certain cases of acute pancreatitis by this mechanism, as does Opie, Halsted, and H. L. Popper.

The pathological changes which are produced by the presence of pancreatic secretion in the bile ducts and in the gall bladder have been investigated, experimentally, by a great number of authors. Conclusive evidence emerges from the biochemical examination of bile collected directly from the bile ducts or gall bladder during operation. The presence of pancreatic juice can be checked by qualitative tests for three pancreatic ferments: amylase, trypsin, and lipase. Most investigators have utilized amylase determinations for detecting the presence of pancreatic secretion because of the relative simplicity with which these determinations can be made, technically speaking. The most common method used is the so called dilution method of incubating equal quantities of carbohydrate solutions with increasing dilutions of amylase (diastase) containing fluid and determining the highest dilution at which digestion still occurs. Such ferment titrations have been carried out by Nordmann, Bundschuh, Ruppanner, Driembowski, Brackertz, Colp, Werthemann, and Westphal. The most extensive examination was carried out by H. L. Popper, who examined 219 specimens of bile gathered during surgical operations and found that 37 specimens or 17 per cent of all the cases gave evidence of pancreatic reflux by the amylase dilution method. Since bile normally contains a small amount of amylase as Hofman noted for the first time in 1845, only high concentrations prove the presence of pancreatic secretion. This concentration must exceed that increased concentration of amylase in bile which occurs during carbohydrate feeding, as discovered by Bonnano in 1908. It is only when the highest, still active dilution of bile exceeds the highest, active dilution of serum, which also physiologically contains small quantities of amylase, that the case can be diagnosed as one of pancreatic reflux. H. L. Popper fixes this limitation at d $38/30=64$. Of Popper's 219 cases, 19 were cases of acute or chronic pancreatitis. Among the 200 remaining cases without pancreatic disease, 20 cases, or 10 per cent, showed the presence of pancreatic ferment in the bile. This means that approximately every tenth case of surgical bile-duct or gall-bladder disease is complicated by pancreatic reflux. In view of the fact that this reflux is anatomically possible in only a limited percentage of individuals, Popper's high figure of the actual incidence of pancreatic reflux proves that this reflux is a rather common complication.

Much less work has been done for the determination of the pancreatic ferment, trypsin, in bile. Technically, the determination is much more difficult than that for amylase and the evidence given by a positive test is not nearly as convincing as that for amylase, for bile frequently gives a positive trypsin reaction especially when it contains a large amount of protein. Another serious drawback is the relatively low specificity of positive findings: for trypsin administered into the bloodstream may be excreted by the liver in the bile; or trypsin may develop from leucocytes in cases of cholecystitis; or lastly, it may come from the duodenum as a result of regurgitation of duodenal contents through the patent papilla. Consequently, only a few trypsin determinations of bile have been reported by H. L. Popper, Hoesch, Westphal, and Loeffler. Erb and Barth examined 50 specimens of bile from cases of cholecystectomy and found that 38 per cent, using the Mueller-Jochmann method, and 74 per cent, using the Fuld-Gross method, were positive for trypsin. These investigators admit that the high positive incidence may have been caused partially by the presence of leucocytes.

A few determinations of lipase in pathological bile have been made. Although lipase does not deteriorate as rapidly as trypsin, as Colp and Doubilet have pointed out, and although it is much more specific than trypsin, for normal bile contains no lipase or only traces thereof (Bonnano, Sobotka) lipase determinations are complicated. H. L. Popper, using the stalagmometric method of Rona and Michaels, found no increase in the lipase contents of bile in a case of chronic cholelithiasis with fat necrosis of the omentum and with a normal pancreas but did find a slight increase of lipase in the bile of a patient with a normal gall bladder, normal bile ducts, and a normal pancreas, who had cramps for 6 years following a laparotomy which revealed edema and hemorrhagic exudate of the pancreas.

Evidence of the presence of pancreatic ferments in the gall bladder proving reflux of pancreatic secretion is of practical and clinical interest only inasmuch as this condition may produce a nonperforative form of biliary peritonitis. It leaves unanswered the question, to what extent is the liver, or better still, are the liver cells, involved by the reflux. The bile ducts, particularly the common duct, are immune against pancreatic secretion. Numerous observations have been recorded concerning liver pathology in cases of pancreatitis and particularly in cases of pancreatic necrosis. In most of these reports, the liver pathology is co-ordinate with the pancreas pathology.

Adamski described multiple thromboses of the portal vein capillaries with miliary hepatic necrosis in a case of pancreatic necrosis complicated by suppurative cholecystitis and cholelithiasis.

Oesterreich investigated a case of initial cirrhosis and moderate jaundice with chronic (scarry) fibrosis of the pancreas. In the mesentery and the omentum numerous foci of fat necrosis were present, but the pancreas itself appeared to be free. The omentum was adherent to the capsule of the liver and, in the field of these adhesions, the liver showed numerous subcapsular triangular areas of necrosis. Oesterreich explains that this necrosis is the result of pancreatic ferments carried to the liver from the pancreas through the adherent omentum, from which numerous small vessels entered the liver surface.

Rudolf published the report of a case of septic endocarditis with multiple small focal necrotic areas in the pancreas and with severe passive congestion and fatty degeneration of the liver. The latter showed small rather nonspecific foci of necrobiosis which Oesterreich describes and explains as septic, mentioning only as a hypothesis the possibility that pancreatic ferments might have reached the liver parenchyma by way of the portal vein. The same hypothesis was raised by Wiesel who found marked focal fatty infiltration with a nonspecific necrosis in the liver in 4 cases of pancreatic necrosis. It is worth mentioning that he saw fat cell emboli in these cases which he traced back to the pancreas in the interlobular branches of the portal vein.

Miller likewise in his case saw fat cells in the intrahepatic ramifications of the portal vein.

Sysak and Nakamura found fat cirrhosis of the liver with old blood pigment associated with pancreatic necrosis; H. Mary found marked and partially focal areas of fatty degeneration of the liver; Rankenberg noted focal passive congestion due to thrombosis of the branches of the portal vein; Eloesser found parenchymatous and fatty degeneration of the liver combined with hemorrhagic pancreatitis.

Truhart, in his book on pathology of the pancreas diseases, reported 47 cases of pancreatic fat necrosis with jaundice. Among these, 12 had either cholelithiasis or obturating tumors of the bile ducts. In the 35 remaining cases, the cause of the jaundice could not be explained. The liver in these patients showed fatty and parenchymatous changes of a nonspecific nature.

Marx observed 2 cases of severe parenchymatous hepatitis with marked focal fatty infiltration and degeneration and pancreatic fat necrosis. He explained the pathology of the liver foci as caused by toxins or toxic products of metabolism carried to the liver by the portal vein.

Eloesser examined cases of his own and reviewed the literature concerning liver pathology associated with pancreatic necrosis. He described the typical liver as one revealing pale yellow, more or less sharply circumscribed areas alternating with dark red, soft, depressed islands on cut surface and microscopically revealing fatty degenerations and congestion resulting eventually in focal necrosis. He points out that such hepatic changes are found frequently in case of severe passive congestion or cirrhosis without pancreatic necrosis. Berner, who investigated the organs of 5 cases of pancreatic fat necrosis, 2 of them with alcoholic cirrhosis, describes marked fatty degeneration involving particularly the periphery of the liver acini. The interpretation of his microscopical analysis seems to be doubtful, since the crescents he described in the sudan stained section are artefacts so

frequently found when this stain is used. However, he did find in some of his cases single fatty acid crystals in the liver which gave a positive green Benda reaction. It is quite likely that some of his cases did contain foci of intrahepatic fat necrosis but that he was unable to demonstrate this because of imperfect histological technique. His paper, which dates back to 1907 when the histological presentation of fat and fat necrosis was not as yet well developed, is the only reference found, which in the descriptions and illustrations gives a clue of specific intrahepatic fat necrosis. However, Berner in the discussion of the findings does not mention this possibility. In a large series of experiments Fischler has noted severe degeneration of the liver in dogs after having established an Eck's fistula and provoked a pancreatic fat necrosis. He found severe centro-acinar degeneration, atrophy, and necrosis, but he emphasizes that he never saw salts of fatty acids, soap or pure fatty acids, which indicate specific fat necrosis. Since in his experiments the portal blood stream to the liver was blocked, he had to trace back the liver pathology to toxic products reaching the liver by way of the lymphatics. This is possible with dogs, for this animal possesses a network of interacinar lymph vessels especially around the central vein as described by H. Popper. Hildebrandt has questioned the experiments of Fischler and tried to prove that the degenerative liver changes are caused neither by the Eck's fistula nor by pancreatic fat necrosis but by the chloroform used for narcosis.

When studying the possibility of proving, by microscopic evidence of liver pathology, the presence of pancreatic reflux into the liver, we must consider the action of the three pancreatic ferments. The action of amylase cannot be demonstrated histologically. The action of trypsin could be proved by necrosis. However, focal necrosis of the liver is very common in such conditions as passive congestion, cirrhosis, parenchymatous hepatitis, etc. when it becomes more severe and tends to lead to yellow or red atrophy. It would be difficult to differentiate focal interacinar necrosis of this nonspecific type from specific necrosis caused by the presence of trypsin. Also it is very doubtful whether pancreatic trypsin coming in contact with liver parenchyma would digest or damage it. In order to develop its specific action, trypsin must first be activated. In the duodenum enterokinase acts as the activator of the trypsin. Bile contains no activator of trypsin as has been pointed out by Oppenheimer. For this reason several authors, Hoesch, Frank, Moynihan and others, believe that simple bile reflux in the pancreatic duct is not sufficient to cause acute pancreatitis. They feel that only if the bile is contaminated by bacteria as a result of a cholecystitis or passage of bacteria from the duodenum through the papilla of Vater will pancreatic trypsin become activated and cause pancreatic necrosis. The causative rôle of cholecystitis in pancreatic diseases has been discussed by E. Starr Judd.

Whereas trypsin needs specific activators, the third ferment of the pancreas, lipase, is much more easily activated. Pure bile can act as an activator and bile salts enhance the fat splitting action of lipase (Fuerth and Schuetz, Terroine, Mellanby and Woolley, Sobotka). Even normal tissues may activate pancreatic lipase as is proved by the fact that numerous cases of intraperitoneal fat necrosis have occurred in which there has been no evidence of mixture of bile with pancreatic juice. This knowledge has been gained from autopsies and has been confirmed experimentally by Frugoni and Stradiotti who produced typical peritoneal fat necrosis in animals by intraperitoneal injection of fresh sterile pancreatic juice, thus proving that neither bile nor bacteria are necessary for the activation of pancreatic lipase. It must be mentioned that Kestner carried out analogous intraperitoneal injections in cats and dogs without producing fat necrosis. However, it appears that there was some technical error in his experiments, for he succeeded in producing fat necrosis in only 50 per cent of his cases when he used equal parts of bile and pancreatic juice. The rôle of bile as an activator of pancreatic enzymes was demonstrated in very convincing experiments by Rewbridge who produced a free flow of bile into the peritoneal cavity in dogs by perforating and opening the gall

bladder. A few days later, when the abdomen was opened he found multiple areas of fat necrosis. The same type of fat necrosis was produced by intraperitoneal injections of sterile bile. These later findings are analogous to those of Frugoni and Stradiotti. However, fat necrosis failed to occur if prior to the opening of the gall bladder, or the injections, the pancreas had been removed. Rewbridge concluded from his experiments that the outflow of bile salts into the peritoneal cavity is the result of an increased permeability of the pancreas produced by the bile salts.

Based on this information, gained from clinical, pathological, and experimental experiences, it seems to me justifiable to expect evidence of pancreatic reflux into the liver when intrahepatic fat necrosis is present in those cases in which the liver contains neutral fat as a result of fatty degeneration or infiltration. Of course, the degeneration present must be severe. When the degeneration is of but a mild degree, the relatively small droplets are surrounded by a layer of protoplasm sufficiently thick that the lipase cannot penetrate through this protecting layer. Only when the liver cell is transformed, that is, into a fat cell consisting of a large drop of fat surrounded by a thin cell membrane can the lipase penetrate through the membrane and split the fat.

I have examined the livers of 16 cases of pancreatic fat necrosis. Since pancreatic fat necrosis usually occurs in adipose individuals, all revealed the presence of fatty degeneration and infiltration. However, the degeneration evidently was not severe enough. In 6 cases there was a periportal hypertrophic cirrhosis with fatty infiltration. In 5 of these cases either the fatty transformation of the liver cells was not severe enough or no reflux had occurred. Finally, the sixth case revealed the changes I had expected to find.

The patient, 65 years of age, was senile arteriosclerotic, and gave a disconnected story. He could not remember many details. For the past 7 years he had suffered from constipation; he had a feeling of abdominal fullness and passed 4 or 5 very small hard stools daily. During the past 2 years, the number of daily bowel movements had risen to 6 or 7. During the past year he had noticed at times bright red blood in his stools; at other times the stool has been very dark brown, but never black, as far as he knew. Also for the past year he had been nauseated most of the time and his appetite had been poor. He had vomited a number of times during the past year. The emeses were usually dark and thick. He did not care to eat and had no particular selective dyspepsia. During the past few months all he had been eating was oatmeal, milk, broth, and the like. Also during the past year his abdomen had been gradually increasing in size (states that he had had to have his trousers "let out" twice) and he had been having practically continuous generalized abdominal pain. He stated that he had not slept a wink for 10 days prior to admission to the hospital. During the past 3 months he had lost 28 pounds (from 168 to 140 pounds). Since his last admission to the hospital 1 year ago, for a carbuncle, he had been troubled with arthritis of the arms, legs, and back. He entered the hospital not because of any particular complaint but because he was run down generally.

Past history revealed that he had had typhoid fever at the age of 15; he had had no venereal disease and drank alcohol in moderation.

Physical examination revealed an emaciated male patient with a typical alcoholic facies, with telangiectasis. He had a constant coarse tremor of his hands. The joints of his fingers revealed chronic arthritic changes. The pupils were round and equal and reacted to light and accommodation. The conjunctiva was pale. Dentition was poor. The tongue was coated and dehydrated; nasal pharynx was negative; tonsils, atrophic. There was present a large firm submandibular mass. The lungs were resonant throughout; the breath sounds, normal; no râles. The heart borders were normal except for widening of dulness over the aorta; rate, 120; tones of good quality systolic murmur at the apex. The abdomen was distended 5 centimeters, with visible veins. There was present diffuse tenderness, no rigidity. Bowel sounds were very quiet; those heard of normal quality, 10 to 20 per minute. The scrotum and testes were negative; the external inguinal rings, normal. The extremities were emaciated with no ankle edema. Atrophic arthritis of fingers was noted. Reflexes showed tissue turgor poor. The blood count showed hemoglobin 70 per cent; red blood cells, 4,200,000; white blood cells, 8,000. Urinalysis revealed no albumin; sugar, none; blood, none; acetone, slightly positive. Microscopic examination revealed an occasional pus cell. Roentgenograms showed paralleling of the small bowel on the left half of the abdomen; no fluid level could be seen; no gas was seen in the large bowel.

The day after admission to the hospital the patient became irrational, did not respond when spoken to, the pulse became imperceptible and he expired 20 hours after admission.

Postmortem examination was made and revealed the following:

The body was that of a moderately emaciated white male. The finger and toe nails were cyanotic.

The midline fat was 40 millimeters in thickness. The intestinal loops were collapsed. The peritoneal cavity contained about 100 cubic centimeters of a dark brown clear fluid. There were small bright yellow spots up to 3 millimeters in diameter over the greater portion of the parietal peritoneum. The peritoneum over these spots was intact and shiny. Subperitoneal hemorrhages distended the mesentery of the large bowel in the region of the splenic and hepatic flexures. The liver was 6 centimeters below the xiphoid and 3 centimeters below the right costal margin.

There were dense adhesions about all the lobes of the left lung. The right lung was free.

The pericardial sac contained approximately 15 cubic centimeters of a clear yellowish serous fluid. The heart revealed a large amount of subpericardial fat covering the myocardium. The mitral valve was slightly thickened and scarred at the edges. The endocardium of the right ventricle was thickened with yellow scarred areas. The coronary arteries were all patent. The walls of these arteries were moderately sclerosed especially the descending branch of the left coronary.

The lungs and the thyroid revealed no special pathological changes.

The mucous membrane of the stomach was pale, reddish purple in color, and was slightly thickened. The mucous membrane of the esophagus was pale pinkish gray in color and presented many small purple elevations up to 3 millimeters in size, originating from distended submucous veins.

The spleen weighed 205 grams and was rather soft. The capsule was thickened in places by white subperitoneal plaques.

The kidneys weighed 400 grams and were soft. The capsule stripped with moderate ease, leaving a pale grayish-purple, slightly granulated surface. The cortex was pale grayish-purple and measures 8 millimeters in thickness. The glomeruli were distinct and the pyramids were purple red, being somewhat darker than the cortex.

The pancreas measured 23 by 5 by 3 centimeters and was firm. The parenchyma everywhere was mottled by dark purple-red hemorrhages, particularly in the tail. The entire gland was surrounded by indurated fat tissue which was mottled all over with bright yellow patches about 2 millimeters in diameter and diffuse purple to black areas of hemorrhages. Both ducts, Wirsung and Santorini, were patent. The former was slightly dilated and even cystic with a circumference of approximately 1 centimeter at a distance of 2 centimeters from its ostium. In this spindle shaped dilatation 4 small irregular, gray, brittle stones measuring up to 2 millimeters were found. The common bile duct and the papilla were patent.

The liver weighed 2,130 grams. The capsule was thickened and studded with small, slightly raised, firm nodules measuring up to 3 millimeters. The intervening tissue showed many small dilated blood vessels and was pale purple-tan in color. On section, the liver parenchyma was found to be entirely replaced by bright yellow-brown, partially confluent nodules measuring up to 1 millimeter in diameter. The intervening tissue was pale reddish-purple.

The gall-bladder serosa revealed a few bright yellow nodules measuring up to 1 millimeter in diameter. The mucosa was smooth and dark green in color. The wall of the gall bladder was thin. The gall bladder contained approximately 30 cubic centimeters of dark green, viscid bile. Microscopically there was evidence of an old chronic cholecystitis of moderate degree with focal fat necrosis of the subserosa.

When the liver was more carefully examined, grossly, on cut surface, a few bright yellow spots, the size of a pinpoint to a pinhead were noticed. When examined with the aid of a magnifying glass, these little areas proved to be of identical structure and color as the foci of fat necrosis in the pancreas and peritoneum, the only difference being that the latter were much larger. To make the intrahepatic foci of necrosis more visible, the old Benda method was utilized. The liver as a whole was cut into twelve slices, the cuts being made parallel to the diaphragm. The organ was first fixed in formalin and afterward immersed for several days in a solution of copper acetate. When the necrotic areas became dark green in color and the slices proved to be fixed and stained thoroughly, the liver was washed in running tapwater and each slice was split into two or three thinner layers. Careful examination of the surfaces of these layers gave evidence of the distribution of the foci of fat necrosis. These foci were found to be more numerous and more closely situated on the inferior than on the diaphragmatic aspect of the liver and more frequent in the middle of the inferior side than toward the edges of that side and also more frequent in the right lobe than in the left. This means that the highest incidence was around the hepatic porta proving that the pancreatic lipase provoking the necrosis evidently invaded the parenchyma of the liver through one of the vessels or ducts which enter the liver at the hepatic porta and split by ramification toward the periphery.

The histological examination of the liver revealed the typical picture of a progressive periportal hypertrophic fat cirrhosis. The periportal tissue was markedly enlarged, showed dense inflammatory infiltration and moderate bile duct proliferation. It included pseudo-acini of oval or round shape, of varying size. The liver cell trabeculæ of these acini presented no radical arrangement. In most of the acini, the single cells contained large fat droplets which replaced the protoplasm to such an extent that the majority of these cells duplicated fat cells in appearance. In some of the acini well demarcated foci of fat cirrhosis occupying one- to two-thirds of the diameter of the acini could be seen. These foci showed neither the red eosin staining of protoplasm nor the violet hemalum staining of the nuclei but revealed a diffuse, cloudy bluish violet staining and a more or less unorganized structure (Figs. 1, 2).

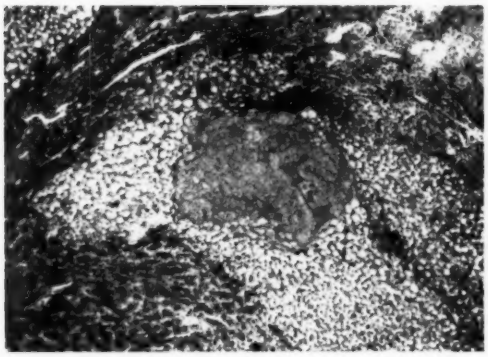

Fig. 1. Small focus of fat necrosis in a large acinus. ×30.

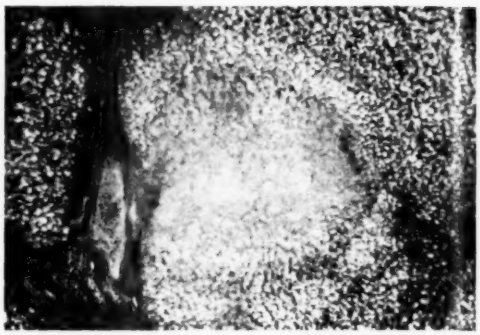

Fig. 2. Large area of fat necrosis at the periphery of an acinus. ×30.

In the frozen sections a large number of fine fat needle crystals could be seen in these foci forming small masses which gave a positive green Benda reaction. Under the polariscope these were double refracting needles (Figs. 3, 4). In the paraffine sections stained with Azan or Mallory's stain, these foci revealed an amorphous yellow staining ground which duplicated, to a certain extent, the acinar structure of the surrounding liver trabeculæ. When stained with argentophil fibers, the network of fibers in the necrotic areas remained essentially unchanged (Fig. 5). This gave support to the evidence that lipase had destroyed the fat only but not the fibrous skeleton of the tissue. Careful examination of a large number of slides revealed a few small liver acini, particularly localized within the thick periportal septa which had undergone a similar but complete fat necrosis (Fig. 6.)

The microscopic examination of the pancreas revealed the typical picture of an acute hemorrhagic necrosis. All over the tissue were scattered irregularly shaped, large and small foci of necrosis with secondary hemorrhages. In the intralobular fat tissue there was a typical necrosis with a positive green Benda reaction. In the glandular tissue the necrotic areas were densely infiltrated by leucocytes, particularly in the borderline zone (Fig. 7). The medium and small excretory ducts were the seat of marked inflammatory infiltration of the muscular wall with partial destruction and partial reactive proliferation of the columnar epithelium and dense leucocytic infiltration of the periductal tissue. The lumen of many of the small ducts contained leucocytes which surrounded oval or spindle shaped, pale pink staining, translucent corpuscles which were produced from the protein of the inflammatory process by clotting and subsequent condensation.

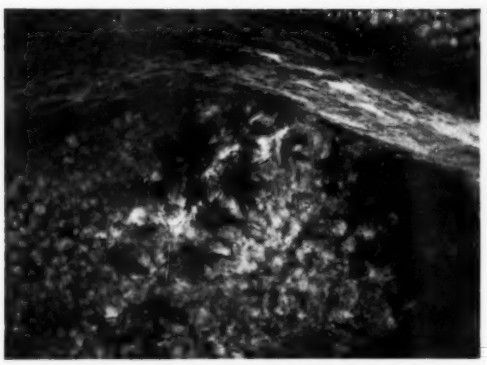

Fig. 3. Fatty acid crystals at the periphery of an area of fat necrosis in the liver. Frozen slide Benda reaction, counter staining with nuclear fast red. ×70.

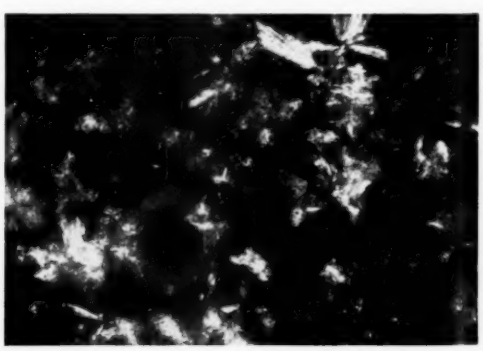

Fig. 4. Liver, intracellular fat necrosis. Fat acid crystals of fat necrosis under the polariscope.[1]

[1] In addition to the long conglomerated fatty acid needles in the fields of necrosis, the polariscopy shows a great number of small single short crystals scattered all over the tissue. Exact examination gives evidence that these crystals lie in the fat drops of the degenerated liver cells, mostly at the periphery of the single drops. These crystals are not specific for the action of pancreatic lipase but develop after a while in all sections of fatty cirrhosis when the tissue is fixed in formalin. I believe that Berner made the mistake of tracing back these unspecific artefacts he found in his case to intravital action of lipase.

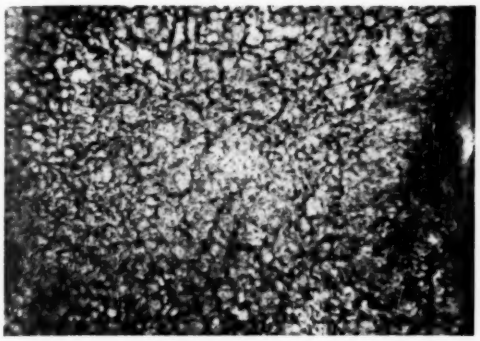

Fig. 5. Intercellular network in an area of intra-acinar fat necrosis. ×65.

Fig. 6. Small pseudo-acinus located in the thickened and inflamed periacinar capsule, completely destroyed by fat necrosis. ×30.

It is very likely that these protein bodies, by secondary precipitation of the mineral salts, gave origin to the little stones found in the main duct (Fig. 8).

Biochemical analysis of the pancreatic stones, by Dr. G. Weber Schimpff of the Biochemical Laboratory of the Cook County Hospital, revealed that they consisted of calcium carbonate mainly with a small amount of phosphates and some organic matter adherent to the surface. (Two of these stones were soft and gray with a jagged, rough surface approximately 4 millimeters in diameter; another stone found was only 1 millimeter in diameter.)

For the presentation of fat necrosis in this case and in many others, the old method of Benda published in 1900 proved very useful. Lapinan, in 1902, found that it was not necessary to use the original fluid which Weigert applied for the presentation of neuroglia but that it was sufficient to fix the tissue in formalin and then immerse it in a solution of copper acetate. Fischler and Gross applied concentrated aqueous copper acetate solutions for 2 to 24 hours at 37 degrees C. This is necessary for the staining of palmitic and of stearinic acid but oleinic acid takes on the stain almost immediately at room temperature. I had the best results by counter staining with nuclear fast red and mounting the frozen sections in a concentrated aqueous levulose solution. A very excellent presentation of fat necrosis can be accomplished by use of Goemoeri's new method (oral communication): frozen slides are immersed in a 2 to 5 per cent aqueous solution of cobalt nitrate or cobalt chloride.

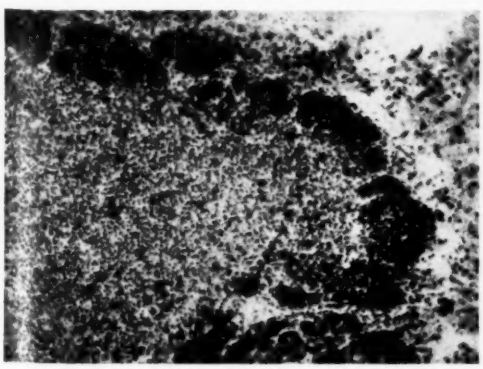

Fig. 7. Focus of pancreatic necrosis with cellular débris in the center and a peripheral zone of well preserved glandular tissue. ×31.

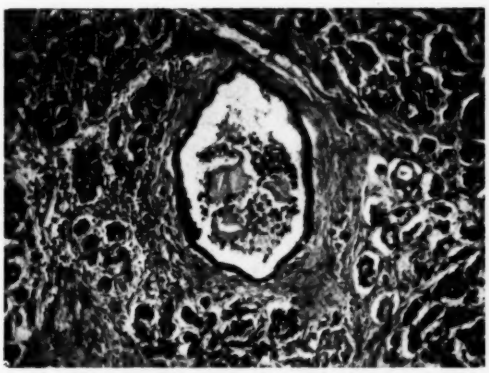

Fig. 8. Pancreatic duct. Inflammatory proliferation of epithelium right side; protein bodies and leucocytes in the lumen. ×65.

Then they are thoroughly washed in distilled water and finally placed in a 1 per cent watery ammonium sulfide solution. The necrotic fat tissue stains dark black and all the other constituents of the tissue remain unstained. As a counterstain nuclear fast red or light green can be used.

In order to utilize the case here reported in the study of pancreaticohepatic reflux, two pertinent questions must be answered: (1) Is the necrosis in the liver specific, i.e. is it produced by the lipase of the pancreas? (2) Did the pancreatic secretion, provided it was the pancreatic lipase that caused the necrosis, reach the liver parenchyma by way of the bile ducts or does the possibility of transportation through lymphatics or blood vessels have to be considered?

Concerning the first question, the possibility of nonspecific fat necrosis has been emphasized. A warning must be given to the examining pathologist not to trace back every necrosis of the subcutaneous, mesenterial, or retroperitoneal fat to the pancreas but to consider trauma, impaired circulation, infection, etc. as possible etiological factors. Nonspecific necrosis of fat tissue has been observed under different conditions and in various organs. Abrikosoff, and Lecène and Moulonguet described fat necrosis and granulomas as a result of disturbed circulation in the subcutaneous fat tissue; Dupont and Perrot described cystic foci of necrosis in the fat of breasts of elderly women; Teutschlander described necrosis of the intracapsular fat of mesenterial lymph nodes, etc. In all these cases the character of the necrotic areas was different from that seen in specific pancreatic fat necrosis. The foci in nonspecific fat necrosis present a granular débris with only a few, small accidental fat crystals and surrounding these foreign body giant cells can be seen. Obviously, in these foci the splitting of the neutral fat is going on very slowly undoubtedly due to the very small quantities of ferment locally produced by the decomposing fat cells and the surrounding granulation tissue. The small quantities of soaps as well as of oleic and sterainic salts which are produced are washed out immediately by the tissue fluids, whereas in specific pancreatic necrosis the following takes place: The lipase at once splits large amounts of fat and thus produces masses of fatty acid crystals long before the surrounding tissue can produce a protective granulation tissue.

The foci of intrahepatic fat necrosis in our case are exactly like those of the pancreatic type. Even though no fat necrosis of the pancreas and the adjacent fat tissue were present, the morphology of the liver foci with the masses of fatty acid needles would point to the action of pancreatic lipase. Necrosis of liver tissue is a rather frequent pathological entity in red and yellow atrophy. However, small necrotic areas are also frequently found in cirrhotic livers. Examination of a large number of slides taken from cases of liver atrophy and cirrhosis, has convinced me that in these cases, as Fischler has already pointed out, the liver tissue never contains fatty acids or fat salts.

Concerning the route by which the pancreatic lipase reached the hepatic tissue, lymph channels can be ruled out, for in the human liver, the lymph vessels, and, as Drinker and Field and Rouviere described, in the periportal field, there are no lymph spaces in the acini, that would be in free communication with the small initial periportal and the larger perivascular lymph vessels. The fluid of the Disse space has to be filtered through the wall of the lymph vessels into the lumen, a process Eppinger calls permeability in one direction. The opposite process, i.e. penetration or permeation of lymph through the wall of the lymph vessels in the direction of the acinar tissue never has been observed and the possibility of such a reversed permeability never proved. In the case of dogs which have a well developed intra-acinar system of lymph channels, the transportation of pancreatic secretion to the liver, through lymph vessels has been proved for example by the experiments of Fischler. Transportation of lipase by the blood stream is not likely since nowhere else in the body were foci of fat necrosis to be found.

H. L. Popper and Necheles, in a recently published paper, have for the first time made accurate determinations of the enzymic content of the peripheral blood and in the thoracic

duct lymph after acute damage of the pancreas. Evidently, the concentration of lipase in the blood is too low to split fat in tissue outside of the pancreas. Even when we admit that the presence of bile produces optimal chances for activation of the lipase, this same process would occur elsewhere in the organism if large quantities of pancreatic lipase were administered by the blood stream. For the reasons stated and because of the presence of pancreatic stones of a size just large enough to block the papilla of Vater, reflux of pancreatic secretion to the liver by the way of the bile duct must be admitted.

SUMMARY

Pancreatic and hepatic biliary ducts may be transformed into one communicating system by obstruction of the outlet—the papilla of Vater. The most frequent cause of obstruction is stones in the common duct; however, spasm of the sphincter of Oddi and edema of the duodenal mucosa must be taken into consideration. Reflux of bile into the duct of Wirsung may cause acute hemorrhagic pancreatitis. Reflux of the pancreatic secretion into the bile ducts has been described as the etiological factor for certain liver changes of different but nonspecific character. That reflux has been proved by amylase determination of the bile. The presence of amylase is indicative in high titer only inasmuch as bile normally contains amylase in low titer, whereas, the presence of lipase in the bile is conclusive evidence of pancreatic reflux, inasmuch as normal bile contains no lipase. In this paper liver-cell fat necrosis as a consequence of lipase content in the bile is described. Lipase in the bile is conclusive evidence of pancreatic reflux, inasmuch as normal bile contains no lipase.

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RECONSTRUCTION OF THE PENILE URETHRA FOLLOWING TRAUMA

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IT is rare for an injury to tear out a large segment of the penile urethra without amputating or destroying the penis.

An enormous number of techniques are available for forming a new penile urethra, based largely on experience with congenital defects, chiefly hypospadias. Godard reviewed all the methods of replacing defects of the urethra. He classified urethroplastic procedures according to the portion of the urethra involved, fixed or mobile: and the source and type of graft employed —stretching of urethra, grafts from prepuce, penis, scrotum, abdomen, thigh, bladder, appendix, saphenous vein, fascia lata, dog's aorta. He found that consistently good results with any one method were exceptional. He evaluated the procedures and considered pedicled grafts from the skin of the penis and the prepuce the best for mobile portions of the urethra and scrotal grafts best for the fixed urethra.

In injuries of the male genitalia, stripping of the skin of penis and scrotum is likely to occur before the urethra can be involved (Cottle's case). If the injury is severe enough to damage the urethra, the best repair materials—penile and scrotal skin, will also be damaged. Reconstructing a penile urethra after an injury, therefore, presents a different problem than does a hypospadias.

Mallard reported a plastic repair to replace 2½ inches of penile urethra, following gangrene due to introduction of a destructive chemical solution into the anterior urethra. Penile skin and one corpus cavernosum penis were destroyed also. He reviewed briefly the literature to date (1930) and found that most of the work was reported by European authors and that little plastic repair of this nature had been recorded in America. Mallard drew no distinction between urethroplastic procedures for congenital defects and those following trauma. After a pedicled tube graft from the thigh had failed to take, he attained a successful result with use of part of the scrotum and a pedicled tube formed from abdominal skin.

Von Rihmer reported a partial necrosis of the penile urethra following an injury which stripped the penis of its entire cutaneous covering and perforated the urethra 5 to 6 centimeters from the external urinary meatus. After clean granulations appeared, suture of the urethral fragments about a catheter closed the defect in the urethral wall. A plastic procedure with the use of scrotal skin to form a new penile covering gave a satisfactory anatomical and physiological result.

U. Heynen reviewed the plastic replacement of urethral defects and gave special attention to perineal hypospadias. He was concerned with congenital defects.

The commonest site of injury to the male urethra is the membranous and bulbous portion. Blows on the perineum cause rupture of the urethra in this region, with or without fractures of the pelvis. The literature on this subject is extensive (Garlock).

Since Mallard's article, there have been few reports of injuries requiring plastic repair of the penile urethra.

ANATOMY AND PHYSIOLOGY

The cavernous urethra is an epithelium lined canal extending from the superficial layer of the urogenital diaphragm to the external urethral orifice. It first enters the bulb of the penis, which lies in the superficial perineal space, passing almost directly forward. It then enters the body of the penis, following the direction of that organ —pendulous in the flaccid state, directed forward in the erect state. The bulbous portion of the urethra is therefore fixed in position, as are the prostatic and membranous portions. The penile urethra is mobile. The cavernous urethra is about 16 centimeters (6½ inches) long, 6.5 centimeters (about 2½ inches) of this being fixed portion. The average diameter of the urethra is 5 to 7 millimeters, and is narrowest at the external urethral orifice and in the membranous urethra.

The two bulbo-urethral glands (Cowper) empty into the beginning of the cavernous urethra. Small pockets of mucous cells in the walls of the cavernous urethra are called the urethral glands (of Littré). Nonglandular pits, called urethral lacunæ, also occur. The epithelial lining of the urethra is endodermal in origin, as it arises from a portion of the urogenital sinus.

Fig. 1. Showing partial destruction of penis, loss of left testicle, scrotum, and 1½ inches of penile urethra. Catheter bridges the urethral gap.

Fig. 2. Skin flap from thigh covering right testicle and raw areas of scrotum.

The lining of the cavernous urethra is a simple or stratified columnar epithelium, with the outer cells becoming squamous in the dilatation of the urethra at its distal end—the fossa navicularis. The submucosa blends with the corpus cavernosum urethra—corpus spongiosum—which consists of highly vascular erectile tissue containing bundles of smooth muscle fibers.

The urethra receives its blood supply from the deep arteries of the penis, which run longitudinally in the corpora cavernosa and give off lateral branches freely. Venous drainage is into the internal pudendal veins.

The urethra serves for the passage of urine and seminal fluid. It must be patent to allow free passage of these fluids and extensible to avoid interference with erection.

ETIOLOGY

Inflammations, malformations, and trauma may produce defects of the penile urethra.

Stricture following a gonorrheal inflammation may be so severe that voiding becomes impossible. The site of those strictures that require surgical intervention is the bulbomembranous segment. Strictures in the pendulous urethra are relieved by dilatation or transurethral incision. In a thousand consecutive cases treated for gonorrhea, Goldstein had 3 cases of urethral stricture necessitating operative interference. He excised the strictured region and passed a rubber tube through the distal and proximal portions of the urethra and across the perineal gap. He found that, in from 8 to 10 days, epithelization of this bare area had occurred over the tube, thus forming a new urethra.

In hypospadias, the external urethral opening is on the ventral aspect of the penis or even as far down as the perineum. Correction of this developmental defect requires the building of a new canal through the penis which will communicate with the lower end of the urethra already present. Many articles on this subject have appeared and have been reviewed by both Godard and Heynen.

The external genitalia and perineum may be injured in many ways. Falls astride loose manhole covers, from horseback, astride fences, from masts of ships, and in many other situations producing blows on the perineum, generally rupture the fixed urethra. Peculiar falls, which cause the clothing and the skin of the penis to be caught, or in which rotating or projecting machinery causes the external genitalia to be caught, may strip the skin of the penis and the scrotum and remove one or both of the testicles. Malicious disfigurement of the penis or scrotum has produced difficult problems (10). Benedict's patient lost most of the skin of the penis through short circuiting of a high voltage electrical current passing through his body.

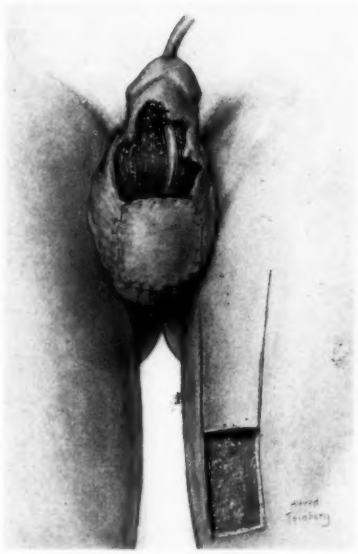

Fig. 3. Pedicle of thigh flap for scrotum severed.

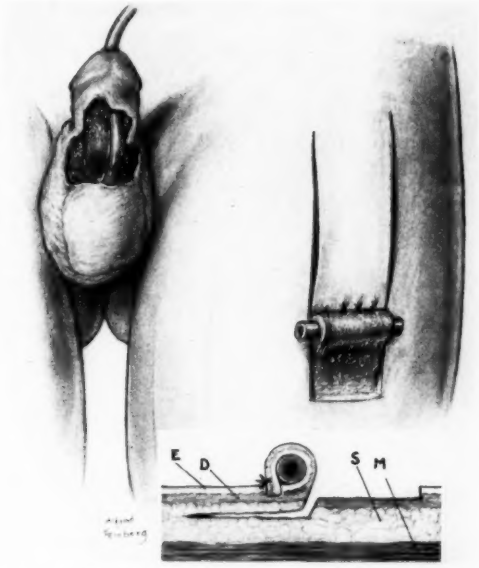

Fig. 4. Formation of tube from skin of thigh, by rolling skin around catheter at distal end of thigh flap. Insert, Diagrammatic drawing of longitudinal section through lower end of thigh flap. *E*, Epidermis; *D*, dermis; *S*, subcutaneous tissue; *M*, muscle.

Blows to the penis when in state of erection may fracture that organ—the tunica albuginea of the corpora cavernosa is torn and a marked extravasation occurs (1, 9). Strong chemicals introduced into the urethra for medical purposes may produce gangrene of the urethra and the adjacent tissues, (Mallard). Automobile accidents may produce any variety of perineal and genital injuries.

SYMPTOMS

The trauma is usually severe and the patient may at first be in shock. There may be an associated pelvic fracture. From the penis itself, bleeding is profuse. Marked pain occurs and the patient is unable to void. Leakage may occur near the proximal segment of the torn urethra.

The extent of the penile damage is noted on inspection. Several days after the injury, necrosis and sloughing of damaged tissue reveal the full extent of the loss of substance that will require replacement.

TREATMENT

Hemorrhage must first be checked. The wound must then be treated as any lacerated wound, depending largely on the amount of foreign material present and the extent to which it is embedded in the tissues. The urinary stream must be diverted, either through a catheter or by suprapubic cystotomy. Where the posterior urethra is the site of rupture, suprapubic drainage is preferable. With the tear in the anterior urethra, however, the proximal segment of the severed urethra is readily located and no difficulty is encountered in intro-

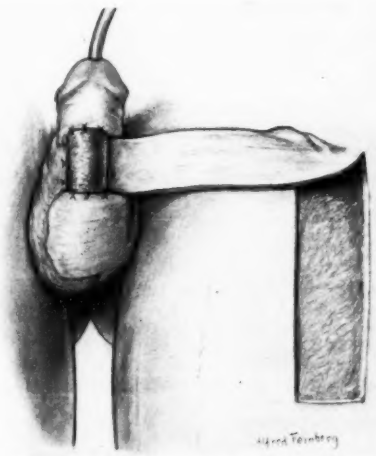

Fig. 5. Pedicled tube from thigh sutured into penile and scrotal defect.

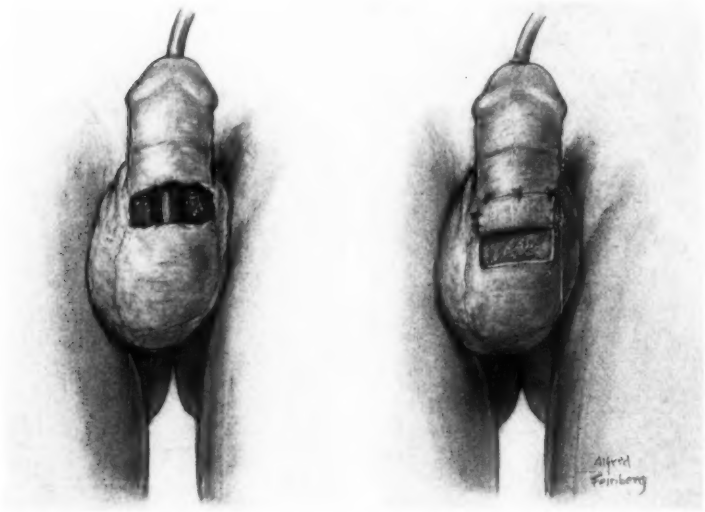

Fig. 6, left. Portion of thigh tube graft has taken, but another portion has failed to take leaving a small defect in urethra and penis.

Fig. 7. Skin flap from scrotum—previously grafted area—reflected over urethral and penile defect.

ducing a catheter to the bladder. We feel that a suprapubic cystotomy under these conditions is needless added trauma and inconvenience.

When clean granulations are forming in the entire wound area, the time for plastic procedure to restore epithelial surfaces has arrived. Due to the rarity of this problem, no simple accepted procedure has been evolved. Comparison of results must be based on observ tions in individual cases widely separated in space and time. Reporting of similar cases is therefore desirable, regardless of the failure or success of any technique or portion of that technique.

Many of the procedures employed in the following case are based on general surgical principles rather than any specific experience with problems of this nature as reported in the literature.

CASE REPORT

An 8 year old schoolboy was struck by an automobile, June 5, 1937, and dragged many feet by the skidding of the vehicle; a wheel ran over his chest, arms, genitals, and legs. He was admitted to the hospital in shock. An extensive brush burn was present over the anterior chest wall, the abdomen, and the front of both thighs, the skin having many particles of sand and dirt embedded in it. The abdomen was held rigid. There was a gaping linear laceration in the left groin, from the anterior superior iliac spine to the pubic crest. The left testicle, with its spermatic cord and epididymis, and most of the scrotum were missing. The right testicle was hanging by its spermatic cord, exposed but otherwise apparently uninjured. The penile urethra, its corpus cavernosum urethræ, part of one corpus cavernosum penis, and the overlying skin, were entirely torn away for a distance of 1½ inches (Fig. 1).

With treatment for shock being carried on concurrently, in the operating room, wounds were cleansed mechanically and by irrigation with normal saline solution, débridement of the scrotal tissues was performed, the laceration in the left groin sutured, and a catheter passed through the remaining segment of urethra into the bladder. Antitetanus and Bacillus welchii serum was given. The patient was kept under an electric light cradle for the remainder of the day and the following night. Three hours after the injury, urine was passed through the catheter. Six hours later, the pulse was of good volume, and the patient definitely out of shock.

Dressings were kept wet with Dakin's solution, and acid sodium phosphate with methenamine (aa. grains 5) were given in water every 6 hours. Dressings were changed every 2 to 3 days.

Due to pain and irritability, all dressings were changed under general anesthesia; cyclopropane was used throughout. The patient was anesthetized 42 times with this gas, for periods ranging from 5 minutes to 1½ hours, without ill effect.

On June 17, 1937, the temperature rose to 103.4 degrees, ranged from 101.2 to 102.6 degrees until June 25, and remained normal thereafter.

On June 25, and thereafter, azochloramide was applied to the dressing.

July 2, 1937, a flap of skin was raised from the left thigh, and the lower portion of the flap was rolled into a tube about a rubber catheter.

July 9, 1937. The edges of the wound of the penis and the area about the divided ends of the urethra were freshened.

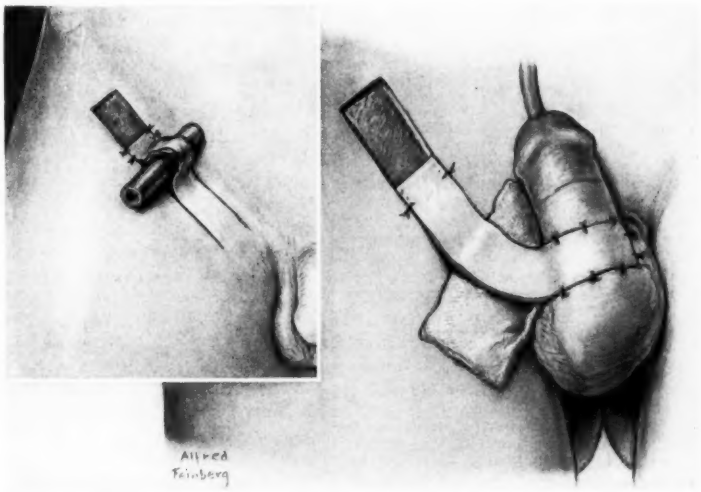

Fig. 8. a, insert, Preparation of sliding pedicled skin flap in right groin. b, Sliding pedicled skin flap from right groin sutured into place in penile and urethral gap. Vaseline gauze placed under the raised and exposed portion of the flap.

July 10. The full thickness skin tube was found too thick to place in the penile and urethral gap. The tube was unrolled, therefore, and the resulting flap used to cover the exposed testicle and the torn scrotal area (Fig. 2). The distal portion of the skin flap was sutured to the margins of the scrotal wound. A plaster cast was placed about both lower extremities, keeping the thighs apart and preventing their movement from the genitalia.

July 24, 1937. The pedicle of the thigh flap was severed, the cut edge of the graft sutured to the adjacent scrotal wound edge, and the pedicle replaced in its thigh bed (Fig. 3). The cast was removed.

July 30, 1937. The new scrotal covering was healthy and healing cleanly at all edges. Healing of the thigh wounds and the scrotum was allowed to progress, with dressings of vaseline gauze changed frequently.

November 6, 1937. The first step in forming a pedicled skin tube to build a new urethra was made. On the anterior aspect of the left thigh, two longitudinal incisions, forming the sides of the future pedicle, were made through skin and the outer layers of the superficial fascia. At the distal end, the incision was carried only into the dermis of the true skin (Fig. 4).

November 11, 1937. The skin was dissected from the fascia between the incisions on the thigh and vaseline gauze placed under the tunnel thus formed. At the distal extremity of the flap, the skin, through the dermis, but excluding fascia, was dissected up and rolled into a tube around a No. 18 French catheter, being sutured proximally to a freshened line of the skin, parallel to the lumen of the tube now formed (Fig. 4, and insert).

November 18, 1937. The distal end of the thigh flap was cut through, the skin tube swung over into the urethral and penile gap, and sutured to the margins of the opening (Fig. 5). A catheter was passed through the entire length of the urethra, new and old, from the external meatus to the bladder. A cast was again applied to maintain immobilization.

November 22, 1937. The pedicle was removed and the tube was sutured along the freed edge. Some sloughing of the pedicle had started.

November 27. A split skin graft was taken from the lateral aspect of the right thigh and placed on the new surface of the penis—now composed of a layer of dermis from the thigh.

December 15, 1937. The major portion of the thigh tube graft had taken, as had the split skin graft over it. At the penoscrotal junction, a portion of the tube graft had sloughed, leaving the urethra without a floor or adjacent penile tissue ventrally for about half an inch of the length of the penis (Fig. 6). Pinch grafts were sutured in place to close this gap and restore the floor of the urethra in this region.

December 29, 1937. Portions of the previously placed pinch grafts had sloughed. They were replaced with new pinch grafts.

January 6, 1938. Pinch grafts had failed to take. The freshly removed prepuce, obtained by circumcizing an infant, was sutured into the floor of the urethra and the penoscrotal gap.

January 26, 1938. The preputial isograft had failed to take, also. A skin flap was dissected from the new scrotum near the base of the penis, reflected, and sutured into the penile defect (Fig. 7). This graft also failed, and a small portion of the scrotal covering was thereby lost.

February 3, 1938. Procedure to form a sliding pedicled skin flap from the right groin was started. Incisions parallel to the right inguinal ligament, about half an inch apart, were made over the lower half of that ligament. The flap was raised over vaseline gauze.

February 16, 1938. The proximal end of the skin flap was severed, transferred half the length of the flap toward the pubic crest, and sutured in the new bed. The distal portion of the flap was raised over a large catheter (Fig. 8a).

February 23, 1938. The pedicled skin flap was sutured into the penoscrotal defect (Fig. 8b).

March 16, 1938. The pedicle was cut. The freed edges were sutured with silver wire.

March 23, 1938. A few new sutures were placed where some gaping had occurred.

March 29, 1938. A single suture was placed at one gaping point of the graft margin.

April 1, 1938. A urinary fistula the size of a match head was still present at the penoscrotal junction. A single pinch graft was placed in the opening.

Throughout the course of this repair, a retention catheter was employed, to keep the lumen of the urethra open and allow a guide for any epithelization that might occur. On April 8, the catheter was removed, as the patient was voiding through the external urethral orifice, with a tiny urinary fistula at the penoscrotal junction.

April 10, 1938. All sutures were removed. A vaseline gauze dressing was applied.

April 12, 1938. Patient discharged from the hospital.

The patient carried on normal activities, voiding through the newly constructed urethra without difficulty. Digital pressure over the tiny fistula at the penoscrotal junction controlled leakage while voiding.

On May 5, 1940, the patient was re-admitted to the hospital, and on May 6, 1940, under cyclopropane anesthesia, the epithelized walls of the fistula were denuded by transverse wedge shaped incisions, the underlying granulation and subcutaneous tissues were brought together tightly with two layers of fine interrupted chromic No. 0 sutures, and a soft rubber catheter was inserted through the urethra into the bladder.

May 10, 1940. The wound was dry, and the catheter was removed. Patient finally discharged from hospital on May 15, 1940.

July 18, 1940. Voiding is normal, and there is no leakage. There is no evidence of stricture. Due to the age of the patient, no definite statement can yet be given as to the ability of the repaired penis to undergo a successful erection. Development of the penis in size and shape is progressing normally.

Search of the literature reveals very few case reports of restoration of penile urethra following trauma. The surgeon faced with such a problem has little to guide him, and even after a fairly extensive study may fail to find the few cases that have been reported.

To restore the urethra, we found pedicled skin tubes from the thigh and a sliding skin graft from the groin, each partially successful. A broad base must be given to the pedicle and sharp torsion of the flap must be avoided. Pinch grafts, employing a successful "take" as the source of a new graft, and an isoplastic preputial graft failed to repair portions of the urethra. A split skin graft from the thigh satisfactorily supplied an outer covering for the penis. A full thickness thigh pedicled graft successfully covered the scrotum and perineum.

Great patience and persistence in repairing partial failures is necessary to attain an ultimately good result.

SUMMARY

The traumatic loss of 1½ inches of penile urethra in a boy of 8 is reported. Adjacent portions of the penis, penile skin, scrotal skin, and one testicle, were also lost. Tubed pedicle flaps from the skin of the thigh and a sliding skin graft from the groin were employed to restore the urethra, with an ultimately good anatomical and physiological result. Reports of traumatic loss of urethral substance in modern literature are rare. Further reports are desirable to improve the technique of repair.

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PARTIAL SELECTIVE THORACOPLASTY AND PEDICLE MUSCLE FLAPS IN THE TREATMENT OF CHRONIC EMPYEMA

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CHRONIC empyema is most commonly the sequel of a previously treated acute empyema. Graham says that all such cases of chronic empyema are preventable. Gray's statement that "with adequate treatment during the acute or subacute stage most chronic empyemas can be avoided," is less dogmatic. Some empyemas are undoubtedly in the chronic stage when they are first seen by a surgeon, the true nature of the acute episode months or years before having been unsuspected. This is particularly true of the loculated and interlobar types.

Accurate diagnosis demands identification of the offending organism or organisms. Such knowledge is also important in planning treatment. Smear and culture of the pus, guinea pig inoculation, microscopic examination of granulation tissue or a section of pleura, aid in establishing the etiological bacteria.

Before planning treatment the extent and position of the empyema cavity should be determined. Aid is obtained by means of roentgenograms taken in the erect and recumbent postures and in the lateral projection. The injection of iodized oil or some other radio-opaque medium may be used to aid in outlining the cavity. Knowledge of the size and position of the empyema cavity so obtained is helpful in planning the incision and subsequent surgical treatment.

According to Carter, three classes of chronic empyema require surgery. These are (1) secondarily infected tuberculous empyema, (2) pyogenic empyema of several years duration, and (3) chronic empyema with bronchial fistula. In this paper only the two last types will be discussed.

SURGICAL TREATMENT

The surgical problem in chronic empyema is to bring the rigid chest wall held fixed by the ribs and thickening of the parietal pleura in contact with the lung. The lung is partially collapsed and its expansion is prevented in part by the thickening of its pleural layer. Establishment of adequate drainage will help to obliterate chronic empyema cavities. Usually, however, "adequate drainage" implies unroofing of the empyema cavity by the resection of overlying ribs intercostal muscle bundles, and thickened parietal pleura. Decortication of the lung (cross hatching the pleural surface) as advocated by Délorme in 1896 is now seldom employed. It is a procedure which carries the danger of air embolism and severe hemorrhage.

Extrapleural thoracoplasty provides a method of indirect attack upon chronic empyema cavities. However, a residual chronic empyema cavity may persist even after thoracoplasty, particularly as a gutter adjacent to the vertebral column. These must be eliminated by some form of unroofing operation. The Schede type of thoracoplasty, which in addition to ribs sacrifices intercostal muscle bundles and thickened pleura is of value in the treatment of smaller empyema cavities, but in the presence of large cavities requires the sacrifice of so much tissue that considerable deformity may result after operation.

The use of pedicle muscle "fills" in chronic empyema cavities was recommended by Kirschner in 1921 and subsequently by Melchior, Eggers, and others. As Carter points out, the method is especially adaptable for large chronic empyema cavities, for those under the scapula, and for others at the apex of the thoracic cage where closure is difficult.

In our hands a combination of selective partial thoracoplasty of the modified Schede type, with subsequent pedicle muscle grafts to fill residual pockets and close bronchial fistulas, has given excellent results in the treatment of extensive chronic empyema cavities. After the size of the empyema cavity and the presence or absence of a bronchial fistula have been determined, the patient is prepared for operation. This requires blood transfusions and a high calorie diet with supplementary vitamins, particularly B and C. Unusual care in pre-operative preparation is essential because these patients all have a limited margin of reserve. Minimal dosage of pre-operative sedatives and morphine are advisable and

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the anesthetic must be chosen with due regard to the presence or absence of a bronchial fistula.

BRONCHOPLEURAL FISTULA

A most serious complication of chronic empyema is bronchopleural fistula. Such a fistula may be the chief factor in maintaining the chronicity of an empyema cavity. Pool and Garlock name pulmonary tuberculosis, lung abscess, bronchiectasis, foreign body, actinomycosis, and gangrene of the lung as additional causes of fistula. The diagnosis of bronchial fistula is usually not difficult.

Bronchial fistulas may close without operation. However, operation is almost always necessary to secure closure of all but the smallest bronchial fistulas. Healing is impeded by infection which commonly accompanies the fistula. When epithelization of the sinus occurs another factor favoring chronicity is added. Several surgical methods of closing bronchial fistulas have been advocated. A most satisfactory plan is that in which a pedicle muscle flap is sewed directly into the fistulous opening. This method is illustrated in reports of Cases 2 and 3 and in the artist's sketches.

ANESTHESIA

Cyclopropane we have found to be a satisfactory anesthetic in operations on chronic empyema cavities. It allows administration of a good anesthetic together with a high oxygen intake, and respiratory effort is minimal. When the empyema is complicated by the presence of a bronchial fistula intravenous sodium pentothal with supplementary oxygen is the anesthetic of choice. In such cases suction through an intratracheal catheter should always be available to aspirate blood or pus which may find its way into the bronchi of the lung not operated upon.

THE VALUE OF STAGED OPERATIONS

Many years ago Robinson soundly warned of the dangers of prolonged operations and attempts to obliterate an empyema cavity in one stage. Three unroofing operations of 30 minutes at intervals of several weeks are preferable to one operation lasting 90 minutes. The manner in which empyema cavities decrease in size between stages of unroofing is often remarkable. The ultimate amount of rib removal necessary to effect complete closure is therefore less following operation in stages than if an attempt were made to remove the entire roof of the empyema cavity at one time. Between operative stages daily irrigations with saline or azochloramide solution is advisable. They help to clean up the cavity and prepare the field for successful transplantation of pedicle muscle flaps at the final operation.

Additional conservation of rib is obtained by the use of pedicle muscle "fills." The latissimus dorsi, trapezius, and pectoralis major are the muscles most commonly employed, depending on the location of the empyema cavity. However, such transplants can be expected to be successful in only relatively "clean" cavities. This would contra-indicate their use at the first stage of most operations. We have encountered no serious loss of function in cases in which pedicle muscle grafts have been used. Care is taken to sew the muscle into the apex of the empyema cavity. Such a maneuver prevents the formation of residual pockets and also gives the transplanted muscle a new point of insertion. In the presence of bronchial fistula a portion of the muscle graft is sewed directly into the fistula opening.

CASE REPORTS

Three typical cases of unusual interest are presented with descriptions of the operative procedures employed. The first is a case of uncomplicated chronic empyema.

CASE 1. R. M., aged 31 years, was admitted to the Philadelphia General Hospital August 10, 1937, on the service of Dr. P. J. McCarthy. The chief complaint on admission was a draining sinus in the left chest. The family history was negative. He had been employed as a mover and a carpenter.

The patient had had pneumonia 10 years before admission which was followed by an empyema involving the left chest. He was operated upon at that time in another hospital and a rubber tube was inserted between the ribs and allowed to drain for 6 to 8 weeks. Drainage gradually diminished and finally ceased after about 1 year. He returned to work but never regained full strength and had always been dyspneic on moderate exertion and susceptible to colds.

In January, 1937, the patient had a severe chest cold and cough which was productive of thin fluid expectoration. During the second week of January, 1937, he developed a severe pain in the left axilla and during a coughing spell his left chest broke open at the site of the old incision and began to drain very foul thick yellow pus. On culture this showed Staphylococcus aureus and no tubercle bacilli were found. The drainage persisted and on admission measured about 6 ounces each day. He had lost 10 pounds in weight and had to stop work 2 months ago.

On physical examination at the time of admission the patient was acutely ill. The temperature was 100 degrees F.; pulse rate, 95; and respiratory rate, 25. The blood pressure was 120/75. The trachea was deviated to the left. A small scar with an opening lined by granulation tissue was noted in the left anterior axillary line at the seventh interspace. The entire left chest was diminished in size, and the interspaces were close together. Scoliosis to the opposite side was noted. There was very little movement of the left chest and on respiration diaphragmatic motion could not be demonstrated on that side. On percussion the entire left chest was dull. Clubbing of the fingers was moderately severe.

X-ray examination showed a chronic empyema cavity with much thickening and calcification of the pleura.

On September 20, 1937, under cyclopropane anesthesia the fourth, fifth, sixth, seventh, and eighth ribs were removed from the chondrosternal junction to the midaxillary line. Following this the patient became dyspneic and required an oxygen tent for 5 days. Drainage from the sinus gradually lessened and he was discharged on October 27, 1937, with instructions to return for further surgery when his strength was regained.

He was readmitted on the service of Dr. J. O. Bower, January 10, 1938. At this time several small fistulous openings were present in the wound and from this purulent material drained. He was transferred to the service of Dr. M. Behrend on March 9, 1938.

On March 15, 1938, under cyclopropane anesthesia the old scar and the wound sinuses were excised. A portion of the third and fourth ribs were removed together with much thickened and calcified pleura and a great deal of fibropurulent débris. The empyema cavity was found to extend under the clavicle. The wound was lightly packed with vaseline gauze and allowed to remain open. The postoperative course was uneventful.

On April 21, 1938, under evipal intravenous anesthesia the wound edges were excised and the granulation tissue around the periphery of the wound was removed. The lower angle of the wound was joined with several silkworm gut sutures. The upper portion of the wound was allowed to remain open and was lightly packed with vaseline gauze. The postoperative course was smooth.

On June 9, 1938, under evipal intravenous anesthesia further plastic excision of the wound edges was carried out (Fig. 1). The lining of the empyema cavity was found to be relatively clean. The skin edges were undermined, thus exposing the pectoral portion of the pectoralis major muscle. This was separated from its insertion on the humerus. A single suture of catgut was placed through the muscle and attached to the pleura at the apex of the empyema cavity in order to obliterate the space. Following this there remained a small pocket at the base of the empyema cavity which was filled with a portion of latissimus dorsi muscle. This too was held in place with a single suture. The wound was closed without drainage. The patient was discharged in good condition on June 21, 1938.

The patient was seen at regular intervals following operation, and on each occasion appeared to be in excellent health. On February 1, 1940, it was stated that his condition was better than it had been at any time in the past 10 years and that he had fully recovered his weight and strength. On the following day the patient was struck by an automobile and instantly killed.

This case demonstrates that a chronic infection of the pleural cavity may lie dormant for many years only to be relighted by the onset of an acute respiratory infection. The value of repeated minor procedures is also demonstrated by this case.

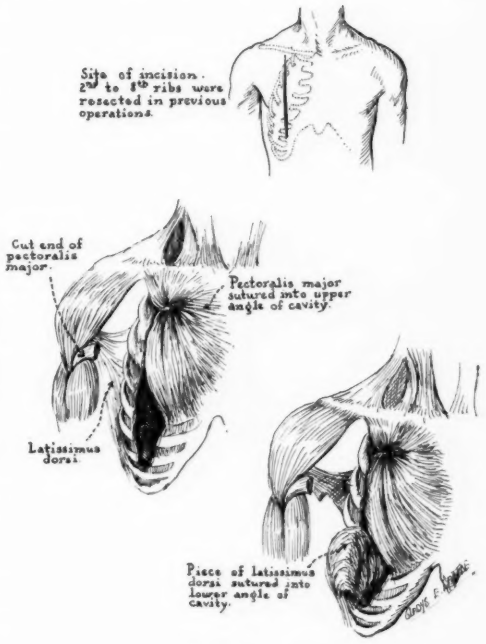
Site of incision. 2nd to 8th ribs were resected in previous operations.
Cut end of pectoralis major.
Pectoralis major sutured into upper angle of cavity.
Latissimus dorsi
Piece of latissimus dorsi sutured into lower angle of cavity.

Fig. 1. Case 1.

CASE 2. J. P., aged 30 years, was admitted to the service of Dr. C. A. Heiken, at the Philadelphia General Hospital on June 10, 1938. The chief complaint on admission was cough and pain in the right chest.

Five months before admission the patient had begun to notice a slightly productive cough which had become increasingly severe and productive of 3 to 4 ounces of thick, yellowish sputum daily. Two months before admission he had gone to a doctor complaining of severe right lower chest pain aggravated by cough. In the past 4 weeks he had lost 7 pounds in weight and for 3 weeks had had night sweats. The past medical history was that of typhoid fever in 1914. In 1928 the patient had right sided pleurisy with pneumonia which was complicated by empyema, requiring surgical drainage. The family history was negative except for the fact that one sister of the patient has had pulmonary tuberculosis for 6 years.

Physical examination on admission revealed a fairly well nourished colored male. He was not acutely ill. However, the temperature was 101.6 degrees F.; pulse 96; respiration, 26; blood pressure, 126/82. Physical examination was generally negative with the exception of the chest. This was fairly well developed and symmetrical. In the region of the seventh and eighth ribs posterolaterally there was a broad 3 inch keloidal scar. Expansion lagged and was decreased in extent on the right side.

X-ray examination revealed a loculated empyema on the right side with probable bronchopleural fistula.

On June 16, 1938 the right chest was tapped and approximately 400 cubic centimeters of thick pus was withdrawn. One hundred cubic centimeters of azochloramide solution was injected. Pus from the empyema cavity showed Staphylococcus aureus. The sputum was negative on four occasions for tubercle bacilli. On June 17, 1938, methylene blue was injected into the pleural cavity and the patient's sputum became stained with the dye.

On June 30, 1938, under cyclopropane anesthesia, the old scar was excised. Regenerated portions of the seventh and eighth ribs were removed (Fig. 2, 1 and 2). The pleural cavity was entered, and approximately 600 cubic centimeters of thick greenish pus was aspirated. A definite bronchopleural fistula was exposed. The wound was lightly packed with vaseline gauze and was not sutured. The postoperative response was good.

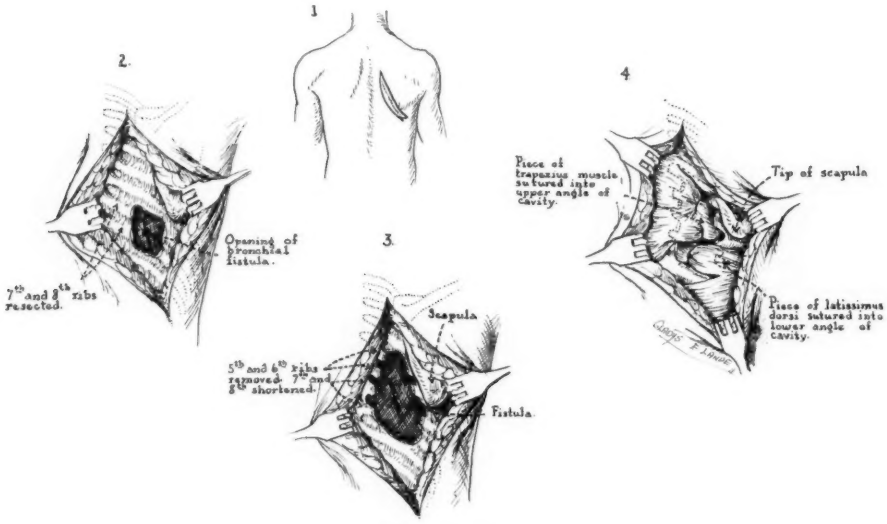

Fig. 2. Case 2.

On July 26, 1938, under intravenous evipal anesthesia the old incision was extended to allow resection of the fifth and sixth ribs overlying the chronic empyema cavity. The posterior stumps of the seventh and eighth ribs were also shortened (Fig. 2, 3). Thickened parietal pleura and intercostal muscle bundles of the fifth and sixth ribs were removed. The wound was lightly packed with vaseline gauze and partially closed with two through-and-through wire sutures. The postoperative course was uneventful. Following this stage, the drainage was greatly decreased.

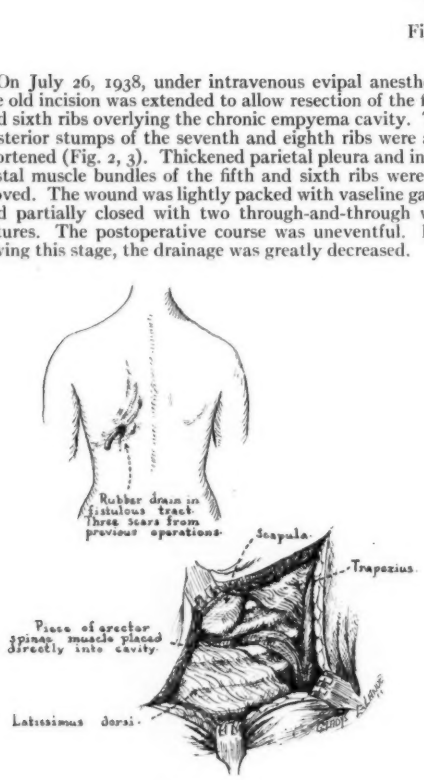
Rubber drain in fistulous tract. Three scars from previous operations.
Scapula.
Trapezius.
Piece of erector spinae muscle placed directly into cavity.
Latissimus dorsi.

Fig. 3. Case 3.

On August 30, 1938, under evipal intravenous anesthesia plastic removal of granulation tissue in the scar was carried out and the remaining portion of the empyema cavity was unroofed. The wound was packed lightly with vaseline gauze and was not sutured. The postoperative course was uneventful.

On November 3, 1938, under cyclopropane anesthesia the scar of the previous operations was excised. The skin was reflected backward on each side of the incision. The remaining empyema cavity was about the size of a hen's egg. In the small amount of pus which was present air bubbled periodically with respiration. A piece of trapezius muscle was detached at one end from the main body of the muscle and sutured into the cavity as a pedicle graft (Fig. 2, 4). Since this did not fill the cavity a similar procedure was carried out using a piece of latissimus dorsi muscle. The muscle was sutured well up into the apex of the empyema cavity and care was taken to sew it directly into the fistulous opening. The wound was closed with interrupted silkworm gut sutures. Convalescence was uneventful and the patient left the hospital 2 weeks after operation. He has returned to his occupation as a chef and reported in February, 1940, that he was perfectly well.

This case demonstrates the value of repeated small unroofing plastic operations in the surgical treatment of chronic empyema. The value of pedicle muscle grafts in the treatment of chronic empyema and bronchopleural fistula is also demonstrated. Undoubtedly their use in this case shortened the period of disability and enabled the patient to return to work in a minimum time.

CASE 3. M. H., aged 33 years, was admitted to the Jewish Hospital March 21, 1939. Her chief complaint on admission was a draining sinus in the left chest. At the age of 4½ years the patient had had pneumonia, and ever since that time there had been some cough and expectora-

tion. At the age of 19 she developed pleurisy with left upper chest pain, fever, cough, and foul expectoration. At the age of 20 she had a similar attack. When 24 years of age she was told that she had an abscess of the lung and was operated upon elsewhere for this. Since then she had had 8 additional operations on the chest together with a left phrenic exeresis, all done elsewhere. At these operations apparently considerable lengths of several ribs had been removed. Despite this the patient continued to cough and expectorate about 4 ounces of foul sputum daily. There had been considerable drainage through a sinus in the chest wall. The patient found it necessary to keep a rubber tube in this sinus to maintain drainage. On several occasions the tube had been lost but was always coughed up through the mouth. The last operation was performed 7 years ago and ever since then the bronchopleural fistula had been draining. A year before this admission the patient had several pulmonary hemorrhages over a period of 2 weeks. The patient's mother died of cancer of the breast, and her father died of cancer of the esophagus. One brother died of diphtheria, while another brother and two sisters are living and well. The patient is unmarried and unemployed. She has always been ill and has shunned society because of sensitiveness about the odor of the drainage.

The patient was not acutely ill on admission. The temperature was 99 degrees F.; pulse, 80; respiration, 22; blood pressure, 130/70. Examination of the chest showed dullness at the left base posteriorly. Opposite the angle of the scapula a deep depression with a hole through the chest wall in which a rubber tube is inserted was observed. Four scars of previous operations on the left chest were noted.

On March 25, 1939, operation was carried out under intravenous pentothal anesthesia with the patient lying on the right side. The fistulous tract was explored and widened. A small chronic empyema cavity was entered at the upper angle of which there was a bronchopleural fistula opening about the size of a lead pencil. There also appeared to be several smaller fistulas below this. The empyema cavity appeared to be relatively clean and had been thoroughly unroofed as a result of the previous operations. Therefore, it was decided to attempt closure of the fistula opening by means of a pedicle muscle graft at this time. However, the latissimus dorsi and trapezius muscles had been largely destroyed and replaced by fibrous tissue as a result of the previous operations (Fig. 3). It was therefore necessary to use a piece of the erector spinæ muscle group which was fashioned into a pedicle graft about 2 inches thick. A suture was taken in the freed end of the muscle and this in turn was sewed directly into the fistula opening. Additional interrupted sutures were taken in the muscle flap to hold it securely in the chronic empyema cavity. The skin was closed by means of interrupted black silk sutures without drainage.

On March 30, 1939, these sutures were removed and there was a moderate amount of drainage from the wound. Following this the wound was irrigated daily with 1:10,000 potassium permanganate solution. On April 10, 1939, the patient was discharged. At this time the wound was practically healed, and drainage was very slight. She was seen in follow-up clinic in April, 1940. The operative wound was entirely healed. Cough had disappeared and there was at the most 1 to 3 drams of sputum raised in the morning but lately even this is occasionally absent. The patient is acquiring an entirely new outlook on life and psychologically is now able to take her place in society.

This case is of interest in view of the many previous operations which had failed fully to obliterate the empyema cavity and to close the bronchopleural fistula. The fact that the patient occasionally lost the drainage tube which was subsequently coughed up is also unique. The long history of pulmonary infection might have led to a rather diffuse bronchiectasis, but the postoperative course has given no reason to believe that it exists.

SUMMARY

1. The factors on which the successful surgical treatment of chronic empyema depend have been discussed.

2. The value of multiple staged operations in the treatment of chronic empyema has been noted. The combination of pedicle muscle transplants with partial selective thoracoplasty has been advocated because it conserves ribs and produces a minimum of deformity.

3. Problems introduced by the presence of bronchial fistula in chronic empyema cavities, together with a satisfactory method of treatment, are also discussed.

4. Three illustrative cases histories have been included.

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A MODIFIED TRANSVERSE INCISION FOR LOW ABDOMINAL OPERATIONS

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THE criteria of a satisfactory operative abdominal incision include (1) an adequate exposure; (2) respect for the structures of the region, so that the wound does not cross the lines of stress and may be strong even before the healing process has been completed; (3) a minimum of postoperative discomfort; (4) simplicity; (5) a cosmetically acceptable scar, if feasible.

The incision here presented is a modification of the Maylard or Bardenheuer incision which, in turn, is an outgrowth of the approach devised by Pfannenstiel. Pfannenstiel's incision satisfies the last four requirements here enumerated, but gives a rather limited exposure. This incision is not practicable in obese patients nor is it suitable for the removal of large tumors or for any work deep in the pelvis.

The Maylard or Bardenheuer incision differs from the Pfannenstiel incision in that all the layers of the abdominal wall—from the skin to the peritoneum—are divided in the same transverse plane. Although it provides magnificient exposure, it has failed to gain favor in this country; its lack of popularity may well be due to the unwillingness of the surgeons to section both rectus muscles, in spite of the fact that the incidence of postoperative hernia following this incision compares very favorably with the end-results of the customary vertical incisions.

The modification to be described overcomes this objection and combines the attractive features of both the Pfannenstiel and the Maylard-Bardenheuer incisions.

The incision through the skin is made like its prototype—a curvilinear incision, beginning from one to two fingerbreadths below and medial to the anterior superior iliac spine, crossing the midline, running almost straight and just within the upper pubic hair line, and terminating below the iliac spine of the opposite side (Fig. 1A). It is developed through the subcutaneous tissue down to the aponeurosis of the external oblique muscle and the anterior sheath of the recti. The vascularity is variable, sometimes only a few vessels require ligation. At either end of the incision the superficial epigastric vein is usually encountered, divided, and ligated.

The anterior sheath of the rectus muscle is nicked on either side of the midline; it is then divided transversely with scissors, and the incision is extended laterally through the aponeuroses of the external and internal oblique muscles, thus exposing the underlying recti in the center and the fascia transversalis and the peritoneum laterally. In the more central portion the aponeuroses of the oblique muscles are fused, but, as the incision is extended laterally, two separate layers will be recognized. The fleshy fibers of the internal oblique muscle come into view about two fingerbreadths from the anterior superior iliac spine where the incision ends. In exceptional cases the muscle may be encountered farther medially, and, since the direction of its fibers is the same as that of the incision, they may be split bluntly. The lower flap of the rectus sheath is grasped on either side of the midline and separated by gauze dissection from the underlying rectus muscles as far as the pubic bones. In the midline, a fibrous septum (part of the linea alba) extends from the deep aspect of the sheath between the contiguous margins of the two recti (Fig. 1B). This septum must be snipped with scissors, with care to remain deep to the aponeurosis to avoid buttonholing that structure; the penalty of a slit in the sheath is a possible postoperative hernia. The pyramidalis muscles are next dissected from the recti.

Near their attachment to the pubis, the recti are fibrous, frequently entirely tendinous (Fig. 2A). They are cut at their very insertion into the pubis. Even in the rare cases in which the muscle fibers are abundant, bleeding is negligible. The muscles are then reflected upward.

The peritoneal cavity is first entered at either end of the incision, under the lower flap of the rectus sheath. By the insertion of the index finger into the peritoneal cavity, the height of the bladder is ascertained, and the peritoneum is incised transversely about one fingerbreadth above the line of its reflection from the abdominal wall to the bladder. In the midline, the urachus is divided, and the rare instances of its patency should be kept in mind. The incision extending from one

From the Departments of Surgery and Anatomy, University of California Medical School.

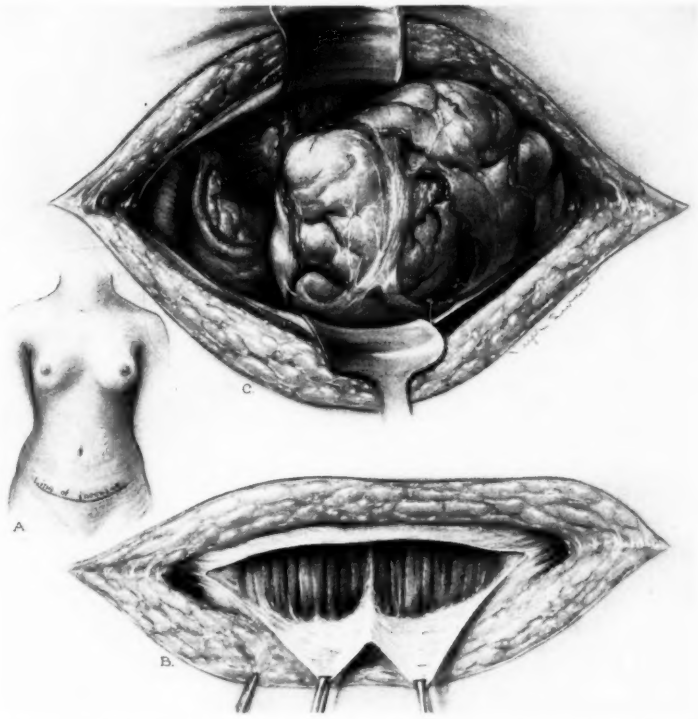

Fig. 1. A, The line of incision. B, Elevation of the lower flap of the rectus sheath. C, The resulting exposure. The tumor was a large ovarian intra-ligamentous cyst which filled the entire true pelvis and projected into the false pelvis.

inferior epigastric artery to the other is usually sufficient, but there is no contra-indication to dividing one or both arteries.

In the closure of the incision, the peritoneum is sutured in the customary manner. The pyramidalis muscles are allowed to fall on top of the peritoneum without any sutures. The ends of the rectus tendons are securely united with mattress sutures to the under surface of the rectus sheath (Fig. 2B). Even in the cases in which muscle fibers predominate at the end of the recti, a preponderance of fibrous tissue will be found in the midline and along both lateral margins. This is the only part of the closure which may prove slightly difficult. However, the table is broken so as to flex the patient's pelvis on the trunk, thus approximating the structures to be sutured. If the operation is performed under general anesthesia, the latter, hitherto very light, must be deepened at this stage; the rectus muscles have retracted and must be relaxed to permit their re-attachment without undue tension. It will be remembered that the recti are firmly attached to their anterior sheath; consequently, if the edges of the upper flap of the rectus sheath are grasped and pulled down, suturing of the lower end of the muscles will be greatly facilitated.

The aponeuroses of the oblique muscles are then closed in a single layer, care being taken to pick up both layers in the lateral portions of the wound. Superficial fascia and skin are sutured in the usual way.

ADVANTAGES

This incision offers several definite advantages. The transverse diameter of the lower abdomen is about 25 per cent longer than the distance from the umbilicus to the symphysis pubis in the male and even longer in the female. Since the resulting exposure is proportional to the square of the axis, the transverse incision is capable of giving an operative field from one and one-half to two times

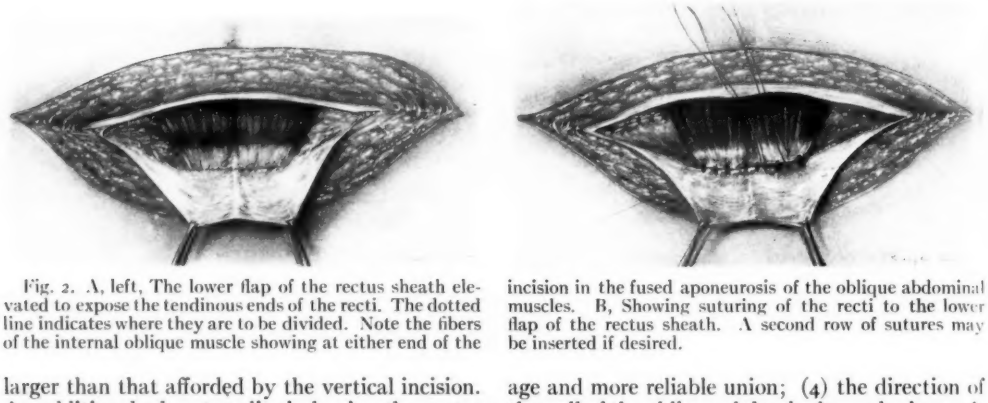

Fig. 2. A, left, The lower flap of the rectus sheath elevated to expose the tendinous ends of the recti. The dotted line indicates where they are to be divided. Note the fibers of the internal oblique muscle showing at either end of the incision in the fused aponeurosis of the oblique abdominal muscles. B, Showing suturing of the recti to the lower flap of the rectus sheath. A second row of sutures may be inserted if desired.

larger than that afforded by the vertical incision. An additional advantage lies in having the center rather than the end of the incision over the operative field. Inasmuch as the overhanging fold of fat found in very obese persons is above the level of the transverse incision, it will not be in the way of the surgeon, thus appreciably decreasing the depth of the wound.

The exposure gives ready access to the lower sigmoid and the upper rectum, the region of the bifurcation of the aorta and the organs contained in the broad ligament (Fig. 1C). Even in the male, the rectum can be mobilized as far as the end of the coccyx under direct vision and without the handicap of working in a deep funnel. Surgeons who favor the preservation of the anal sphincter, as in the Devine procedure for excision of carcinoma at the rectosigmoid junction, will be able to remove more of the rectum and to achieve an anastomosis deeper in the pelvis than can be accomplished with the use of the vertical incision.

The incision described is not intended for general exploration of the abdominal cavity, but it will permit palpation of the liver and the performance, if desired, of the incidental appendectomy, unless the appendix is located unusually high. Exceptionally large pelvic tumors extending to the umbilicus would also be difficult to deliver through this incision.

The strength of the abdominal wall following this approach results from 4 factors: (1) no part of the muscle is denervated—the pyramidalis is of little account; (2) the aponeuroses of the oblique abdominal muscles, the recti muscles themselves and the peritoneum are divided at different levels—in a staggered incision, the layers of the abdominal wall are not weakened in the same place; (3) all the sutures are taken in tendinous structures which offer more secure anchorage and more reliable union; (4) the direction of the pull of the oblique abdominal muscles is parallel to the direction of the incision in their aponeuroses. Consequently, the line of suture in this most important layer of the anterior abdominal wall is subjected neither to the constant strain of muscle pull, nor to the sudden disrupting jerk during a paroxysm of coughing. The incidence of evisceration or postoperative hernia should be negligible.

The low abdominal incision is also attractive from the point of view of anesthesia. As the incision is below the level of the eleventh segment of the thoracic cord, spinal anesthesia need not extend higher; accordingly, there is less depression of the blood pressure. If general anesthesia is employed, it may be light, except when the rectus muscles are being re-attached; no muscular relaxation is required at other times because the contraction of the muscles does not tend to close the wound. The edges of the wound gape without the aid of retractors. Very little packing is required to keep the small intestines out of the field and, for this reason, there is less tendency to postoperative distention.

The lower abdomen is not used much in respiration even by men. Consequently, the pain of a low abdominal wound is not aggravated by breathing and will have almost no inhibiting influence on respiration. Since the incision is relatively painless, the requirement of narcotics is diminished—a pillow under the patient's knees for the first 2 days will further reduce postoperative discomfort. No adhesive strapping is needed above the iliac crests, thus further promoting better pulmonary ventilation. The surprising freedom with which the patient moves in bed after operation can be easily explained by the consideration of the anatomical factors involved: the patient turns by the use of the oblique abdominal muscles; since they do not tend to pull

the incision apart, their contraction does not produce pain. These same muscles are the ones primarily concerned in coughing; therefore, the patient has less dread of expectorating. The combination of relatively painless motion, respiration, and coughing leads one to expect a very low occurrence of pulmonary complications.

For those patients who judge the merits of an operation by the appearance of the scar, this incision is particularly desirable; the part which is not hidden by the pubic hair follows the natural skin lines and will eventually merge with these lines.

SUMMARY

A transverse low abdominal incision for clean cases is described which combines the following advantages: (1) very wide exposure, (2) strength, (3) no need of muscular relaxation, (4) less inhibition to respirations postoperatively, (5) technical simplicity, and (6) good cosmetic result.

I wish to thank Dr. John B. de C. M. Saunders for his suggestions and constructive criticism.

PRACTICAL POINTS IN THE DIAGNOSIS AND TREATMENT OF FRACTURES OF THE JAWS

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ONE of the conspicuous clinical observations in the field of traumatic injuries during the past two decades has been the increasing incidence of fracture of the maxillary bones. This fact is but a natural consequence in an economy which is characterized by a highly geared industrialism with the emphasis on speed. The all too frequent failure to diagnose correctly such fractures may be attributed in a large measure to a lack of acquaintance with the fundamental principles of treatment. That hospital administrative boards are recognizing the need for specialized handling of these fractures is evidenced by the growing tendency to appoint competent oral surgeons to the consulting staff.

GENERAL CONDITIONS

Fractures of the jaws possess the inherent possibility of serious complications. The fractured maxilla is more prone than the mandible to have associated skull or brain injuries. The most serious complication is a fracture of the base of the cranium which, besides being often accompanied by brain injury that may of itself be fatal, leaves an open avenue to intracranial infection (1). Cellulitis and osteomyelitis may develop, especially when the lower jaw is the site of injury. In order to determine properly the type and degree of injury both a clinical and roentgenographic examination should be instituted. Since the trauma often involves contiguous structures, a digital examination of the facial bones should be made. By means of the thumb and forefinger the maxillary, malar, and nasal framework can be outlined. Fractures of the zygomatic arch that are obscured by swelling may often be detected by tracing the orbital borders. Particularly should there be an intra-oral inspection of the dental arches.

The most commonly observed and significant sign of fracture of the jaws is the inability to approximate the teeth in a normal manner. Some of the other symptoms are tenderness at the point of injury, ecchymosis, mobility of the parts, and loss of function. When the traumatizing force has been great enough, injury to branches of the fifth nerve results causing paresthesia of those areas in which it innervates. Clinical examinations should always be supplemented by a roentgenographic survey. The mandible, in particular, lends itself to study by means of the roentgen ray. However, two lateral jaw exposures are insufficient; only when additional views of the symphysis and ramus, including the coronoid and condyloid processes have been made, can the survey be considered complete and adequate for diagnostic purposes. Fractures of the maxilla are not as easily determined by the roentgenogram because of the overlapping of the cranial bones which tends to blur the fracture lines. Therefore, the importance of a careful clinical examination is obvious.

THE MAXILLA

The upper jaw is less frequently the site of fracture than the mandible. This may be ascribable to the more pronounced position of the latter and to the natural protection and support afforded the maxilla by the adjacent bones. Anatomically it consists of two maxillæ, together forming the upper part of the face and containing the antra of Highmore. Although frailly attached to the skull, it is strongly supported posteriorly by the frontal, the sphenoid, and temporal bones. Not only do these buttresses tend to prevent injury from blows delivered from in front, but they also serve to absorb and disseminate shocks, thus alleviating the deleterious effect on the cranium.

Fracture of the maxilla may involve only the alveolar process or may be so extensive as to detach the whole jaw from the skull. When displacement is marked, it is due more to the original violence and gravity than to any muscular force. Often associated with the injury, particularly in complete transverse fractures, is fracture of the malar bone. Hemorrhage into the antrum, loss or devitalization of several teeth, and lack of sensation of parts of the face, are symptoms frequently observed.

The treatment, except in oblique fractures of the maxilla, may be conveniently administered by utilizing intra-oral methods of immobilization, details of which will be discussed later. When

Read at the second clinical meeting of the John Taylor Bottomley Medical Society, the Carney Hospital, Boston, Massachusetts, October 25, 1939.

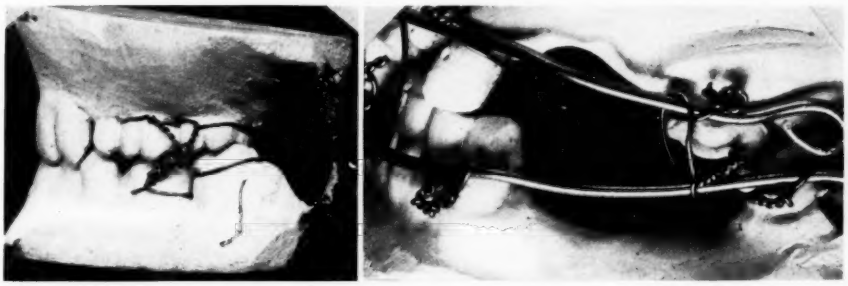

Fig. 1. Gilmer methods of wiring. a, left, No. 1 method, wires twisted about neck of adjoining teeth, crisscrossed, and joined to wires similarly arranged below. b, No. 2 method, metal splints attached by fine wires to upper and lower arches. Intermaxillary tie wires connect splints.

the line of fracture runs transversely through the maxilla or higher up through the orbits, the necessity for support obtained from outside the mouth becomes apparent. In these patients the entire jaw hangs loosely by the soft tissues, the face presenting an elongated appearance. From a headcap of leather or other material, with the skull as a point of anchorage, connection is made with a metal splint previously attached to the upper dental arch. Thus, upward traction on the maxilla can be exerted which anatomically restores the natural facial contour. That the normal relation of the teeth of the upper and lower jaws should be re-established is axiomatic and fundamental. Because deformity may result, fragments of bone should not be removed unless wholly detached, as the richly nourished maxilla tends to heal with surprising rapidity.

THE MANDIBLE

Of all the facial bones the mandible, although the largest and strongest, is most often fractured. Injury may occur at any point from the symphysis to, and including, the condyle. The most constant site of fracture is the angle; the next most common location is the region of the mental foramen. Statistical studies have revealed that bilateral fractures usually involve both these regions (4). Fractures of the body of the mandible are generally compound, communication with the oral secretions being through lacerations of the mucous membrane or the sockets of the teeth. The majority of the edentulous cases are of the simple type, yet present mechanical problems in immobilization. Although displacement in fracture of the mandible is primarily caused by trauma, it is accentuated by the strong traction of the many muscles to which the jaw gives attachment. The anterior fragment is depressed by the suprahyoid group while the ramus is elevated by the masseter, internal pterygoid, and temporal muscles. Even the slightest displacement causes disruption of the normal articulation of the teeth. Steering-post accidents are a potential and increasing cause of injury to the condyle. Fracture of the neck of the condyloid process is

Fig. 2a. Fracture of mandible with displacement of ramus.

Fig. 2b. Same case after reduction with metal splint and elastic traction.

Fig. 3. Fracture of maxilla of 12 year old boy. Reduction by means of Gilmer method.

the result of indirect force; fracture of the symphysis is sometimes co-existent. Unless precluded by the direction of the fracture line, the head may be displaced from its normal position in the temporomandibular fossa. The most characteristic symptom is deviation of the chin toward the affected side; shortening of the ramus on the same side is a logical consequence.

TREATMENT

The management of fractures of the jaws has for its aim the overcoming of muscular pull by restoring and maintaining the parts in proper position. When teeth are present, it is a basic rule to re-establish occlusion which requires careful and accurate reduction. The vast clinical material of the World War furnished an unusual opportunity for the study of jaw injuries. Since immobilization is mainly a mechanical problem, the choice of method should be the simplest and most effective means possible. The procedures used today are modifications of the basic ideas of Gilmer, whose principles in the treatment of fractures still remain classic. The first method which he advocated consists in looping a wire around the neck of a tooth and twisting the ends together. This operation is carried out on two adjoining teeth and similarly on the occluding lowers. The wires are crisscrossed before winding the upper and lower ones together; meanwhile the occlusal relations are secured. The Gilmer second method involves the adaptation of a metal splint to the teeth of each jaw by threading fine wires around the necks of the teeth. Intermaxillary tie wires connect the splints and firmly hold the jaws in position. Because of the successful results obtained, especially in badly displaced instances, there is an ever growing tendency today to use intermaxillary elastic traction.

These methods are equally applicable to the treatment of partial fractures of the maxilla, the basic tenet of treatment which remains the same. Clinical experience has shown that the Barton and other type of head bandages are of little value, except as a supplementary aid to some other form of fixation. The pressure of a bandage is inclined not only to cause pain but in some cases actually to increase displacement of the fragments. The majority of the fractures of the mandible can be treated by non-surgical means as we have illustrated. Surgical intervention is for the most part limited to certain types of edentulous cases, the management of which was discussed in detail in a previous paper (2).

The postoperative care consists in maintaining good oral hygiene, giving adequate attention to the diet, and preserving the general health of the patient. Loss of weight during the early period of immobilization is a common observation. Occasional adjustment of the stabilizing devices is necessary to maintain correct alinement of the bone. Such complications as osteomyelitis and malunion can often be avoided by the maintenance of ample drainage of all suppurating areas. The usual period of immobilization is about 5 weeks (3).

SUMMARY

The diagnosis and treatment of fractures of the mandible and maxilla necessitate the employment of both a clinical and roentgenographic examination. A complete roentgenographic survey is essential, particularly of the lower jaw. The basic principles of treatment are predicated upon the accepted concept of restoring the normal relation of the teeth, thereby satisfying both functional and cosmetic requirements. That many cases are complicated by infection, delayed union, malunion, and in some instances nonunion is attributable in a large degree to a lack of knowledge of, or deviation from, the cardinal principles of treatment advocated by Gilmer.

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A STRAIGHT LATERAL INCISION FOR UNILATERAL SUBOCCIPITAL CRANIOTOMY

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SINCE craniotomies are at best time consuming procedures, I believe it worth while to call attention to a straight lateral musculocutaneous incision that I have employed for several years in performing unilateral craniotomy. It has definite advantages over both the curved and Cushing crossbow types of incisions, since it can be made more quickly and closed more rapidly than either of the two. It affords equally as good exposure and even stronger closure, since the incision is muscle splitting rather than muscle cutting.

The incision has become of more significance since unilateral suboccipital craniotomy has become an accepted operative procedure in exploring the cerebellopontine angle. The approach is used chiefly for performing subtotal section of the eighth cranial nerve in Ménière's disease and total section of the ninth cranial nerve for glossopharyngeal neuralgia. It is also used in performing section of the trigeminal nerve and for tractotomy, and we of the Section on Neurologic Surgery are employing it more and more in operating for acoustic neurinoma.

In preparing the patient for operation, I prefer to have ether administered by the drop method over a Magill tube which has been introduced into the trachea. As soon as the patient has been anesthetized I prefer the use of the cerebellar upright position (Fig. 1) to the use of the horizontal position because, if the former is used, the occipital region will be on the same plane as are my eyes during the operation. The musculocutaneous bleeding also will be much less. The use of the large intratracheal tube and the upright position prevents venous congestion and anoxemia which, in turn, reduces the intracranial pressure and eliminates the frequent need of aspiration of the lateral ventricle and the administration of hypertonic solutions. If orthostatic hypotension exists, the cerebellar upright frame will have to be tipped forward to lower the head during the operation.

TECHNIQUE OF STRAIGHT LATERAL INCISION

After the surgical field has been prepared and draped, the following structures are identified; the mastoid prominence, the superior occipital ridge, the external occipital protuberance and the lateral border of the trapezius muscle. The incision begins 3 centimeters to the right or left of the occipital midline and 2 centimeters above the superior occipital ridge. It is then extended downward into the neck to a point opposite the spine of the axis. The incision, though straight, takes a lateral course to end between the trapezius and the sternocleidomastoid muscles, but does not incise the splenius capitis and cervicis muscles. The incision is made to extend through the scalp, fibers of the occipitalis and transversus nuchæ muscles, and periosteum.

Bleeding of the scalp is controlled by digital pressure until the scalp hemostatic clips are applied. The occipital artery and veins are ligated with catgut. The smaller vessels are electrocoagulated. The occipital bone is exposed by freeing and retracting the periosteum and muscles *en masse*. Unilateral craniotomy from this point may be extended in any desired direction (Fig. 2a). In exploring for tumors of the cerebellopontine angle I prefer to extend it toward the midline in order to decompress the medulla oblongata and to elevate the cerebellar tonsils, if such exist (Fig. 2b).

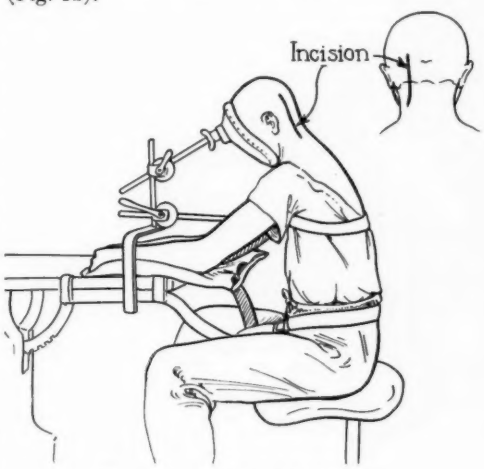

Fig. 1. Cerebellar upright position

From the Section on Neurologic Surgery, the Mayo Clinic.

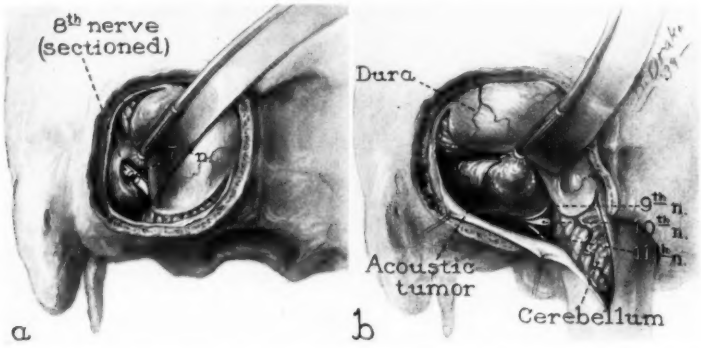

Fig. 2 a, Unilateral suboccipital craniotomy (section of eighth cranial nerve); b, unilateral suboccipital craniotomy (exposure of acoustic tumor).

CLOSURE OF THE INCISION

A continuous suture of No. 1 catgut can be used in closing the muscle planes, since they have been split rather than incised. The one exception is the small transversus nuchæ muscle. The fascial planes superficial to the muscles and the periosteum cephalad to the muscles and galea are closed with interrupted sutures of silk. The dermal closure may be of continuous or interrupted silk sutures. The dressings used are those of sterile gauze fastened with adhesive. The muscle splitting incision is much less painful after operation than the transmuscle section incision. The patients are permitted to be up and about on the third postoperative day and they are allowed to move the head and neck as much as they please without any fear of the incision being torn open.

HAMMER-TOE

A New Procedure for Its Correction

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ALTHOUGH many operations have been devised for the correction of hammer-toes, the most generally used procedure is a simple wedge resection of the proximal interphalangeal joint. Following this operation the toe must be splinted in the corrected position approximately 6 weeks for bony fusion to occur. Jones advises a wedge shaped resection of the joint with the base upward, division of the flexor tendon, and fixation of the toe to a splint. He advises that the patient walk about, wearing the splint on the inside of his boot in order to make sure that solid ankylosis occurs without any return of the deformity. However, it is difficult to splint a toe properly while the patient is in bed and much more difficult to splint efficiently the toe of an ambulatory patient. One cannot ask a patient who has had the relatively minor operation of correction of a hammer-toe to remain in bed for 6 weeks. If, through faulty immobilization, fibrous ankylosis occurs, the result may be clinically satisfactory, but there is always the danger that the deformity may recur.

Many surgeons have attempted to improve, by various devices, the methods of splinting in common use. Lake advised the application of a splint of stout iron wire bent to fit the parts. He advised that this be kept on for 2 weeks after which strapping may be used as a substitute. Trethowan advised collodion and gauze-strip dressings, changed every 2 weeks for a total of 6 weeks. Creer devised an ingenious fork-like splint of duraluminum which fitted on the dorsum of the foot but divided at the cleft of the toe into the two lateral prongs to which the toe was bandaged.

It has been suggested that a silk suture be placed about the proximal phalanx at the time of operation and brought out through the plantar surface of the toe where it could be tied about a plantar splint. This proved impractical in my hands, as the immobilization was not satisfactory, both the suture and the splint moving about when the patient walked.

Several operations were devised with the express purpose of obtaining internal splinting.

I was impressed by an ingenious, but rather complicated, operation described by a French orthopedist, Tierney. He used the principle of spiking the distal end of the proximal phalanx into a rotated portion of the phalanx itself in an attempt to maintain correction without splinting. I attempted the procedure several times, but had difficulty in maintaining the spike in its socket.

Young and Higgs independently described a less complicated spike operation which offered the same difficulty as the Tierney procedure. I found it difficult to obtain and maintain a snug fit of the spiked end of the proximal phalanx in the cavity in the middle phalanx.

In an attempt to obtain a more satisfactory method of splinting, I devised an operation that permits efficient immobilization in the corrected position in an ambulatory patient. In some cases the patient was operated upon and permitted to walk the next day in a cut-out shoe. Unless there are contractures of the metatarsophalangeal joint

From the orthopedic service of Mount Sinai Hospital.
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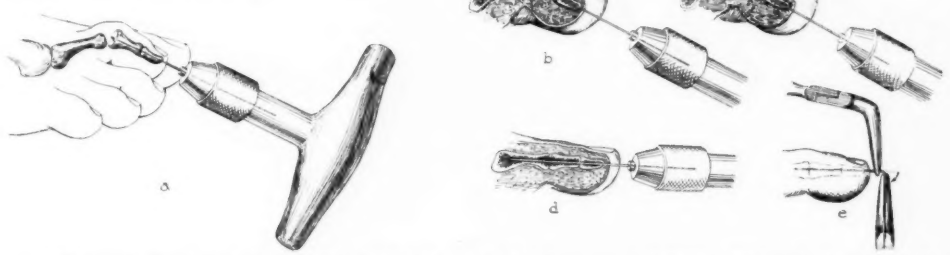

Fig. 1. a, Schematic drawing of the wire, the chuck and its method of insertion after the proximal interphalangeal joint has been resected. b to e, Schematic drawing of the subsequent steps in the operation.

Fig. 2, left. Showing the postoperative position of the wires on anteroposterior and lateral projection in Case 1.
Fig. 3. Bony union in the corrected position in Case 1.

to be overcome by capsulotomy or tenotomy, the patient need not stay in the hospital after the operation. I have performed the operation on 20 toes in 10 individuals in the past 6 months, and the results have been satisfactory. While the period is too short for a long term follow-up, bony union was obtained in all the cases in which the procedure was properly carried out. Local or general anesthesia may be used, according to the indications. If local anesthesia is used, it is unwise to use a tourniquet about the base of the toe because of the remote possibility of gangrene following the combination of local anesthesia and a tourniquet as described by Garlock.

Through a medial longitudinal incision over the proximal interphalangeal joint the articulation is exposed. A transverse incision may be used if desired and is especially satisfactory if a heavy corn is present over the joint, as this can then be excised by an elliptical transverse incision. Theoretically, the longitudinal incision is less likely to interfere with the blood supply of the toe, but in many toe operations for other conditions I have seen no circulatory disturbances following a transverse incision. No circulatory difficulties occurred in the present series of cases in which the average age was 38 years and varied from 11 to 64 years. The cartilage is then carefully and completely removed from the opposing articular surfaces, preferably with a small osteotome and curette, and this usually permits correction of the deformity. If the angulation cannot be readily corrected, bone should be removed from the proximal phalanx. Remove merely enough bone to obtain correction of the angulation, but do not resect too much bone, as laxity is to be avoided. Because the smallness of the middle phalanx makes it difficult to carry out the procedure to be outlined, as little bone as possible should be removed from this part. Any deformity of the distal joint can be corrected by manual stretching. A Kirschner wire, 35/1000 of an inch thick (Fig. 1a) is then inserted, by means of a hand chuck, longitudinally through the tip of the toe, through the distal phalanx, through the distal interphalangeal joint and through the middle phalanx until the point of the wire appears at the denuded proximal surface of the middle phalanx. If the bones are unusually large, a wire, 45/1000 of an inch thick, should be used. The wire is inserted by a rotary movement of the chuck. Strong pliers must be used to fasten the wire in the chuck or it will tend to rotate in the chuck rather than penetrate the bone. It takes some

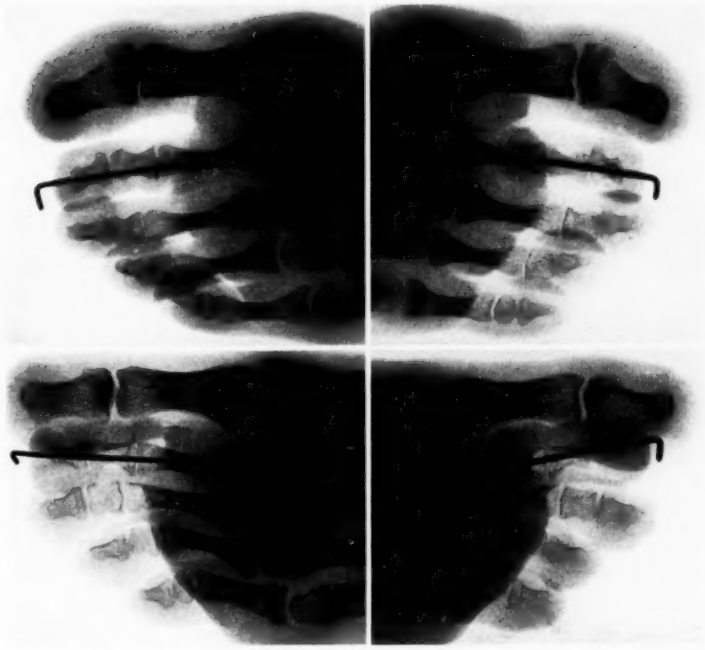

Fig. 4. Postoperative position of the wires in Case 2. Bilateral anteroposterior and lateral views.

practice to insert this wire correctly even under direct vision, and if the point of the wire does not appear approximately in the center of the denuded surface of the middle phalanx, another attempt should be made. In some cases three or four attempts were necessary before the wire was properly centered. No ill effects followed the multiple passages of the wire, and motion in the distal interphalangeal joint was only slightly or not at all impaired after the withdrawal of the wire 6 weeks later. If the point of the wire appears at the denuded proximal surface of the middle phalanx, the chuck is carefully released with the aid of pliers to avoid the inadvertent disturbance or withdrawal of the inserted wire. An additional length of wire, corresponding to two-thirds of the length of the proximal phalanx, is now permitted to extend from the chuck. The length of the average adult proximal phalanx of the second toe is between 1 inch and 1¼ inches. Therefore, if approximately 11/16 of an inch of wire is inserted into the proximal phalanx, sufficient immobilization is obtained, and there is no danger of crossing the metatarsophalangeal joint. If the operation is carried out on the other toes, the surgeon must, by clinical and x-ray measurements, estimate the length of wire to be inserted into the proximal phalanx (Fig. 1b).

Carefully, to avoid disturbing the partially inserted wire, the chuck is again tightened with pliers, and the point of the exposed wire is then carefully placed at the center point of the denuded distal surface of the proximal phalanx (Fig. 1c). This position of the point of the wire is maintained, the deformity is corrected, and the wire is driven longitudinally through the proximal phalanx by the same rotary motion of the chuck (Fig. 1d). If, by any chance, the wire is not centrally placed in the proximal phalanx, it should be carefully withdrawn until the point again protrudes from the middle phalanx, and the procedure repeated. If the operator is satisfied that the wire has been satisfactorily driven, the resected joint should be inspected. The joint must be flush and the two phalanges firmly fixed to one another without any intervening space. If motion between the two phalanges can be demonstrated, one can be certain that the wire has not been properly placed. By means of two small right angle pliers the projecting end of the wire

Fig. 5. Union in the corrected position in Case 2. Bilateral anteroposterior and lateral views.

should be carefully bent to a right angle and the excess wire cut off (Fig. 1e). This last step is to prevent the possibility of the wire wandering deeply into the tissues. I have experienced no wandering of the wires except in those cases in which the wire inadvertently crossed the metatarsophalangeal joint. A small longitudinal strip of gauze is now placed over the wound, extending around the end of the toe to the plantar surface, and the projecting end of the wire is permitted to extend through the gauze. Collodion is used to fasten the gauze to the skin, and no further dressing is necessary except two small strips of adhesive over the projecting end of the wire to prevent its catching in objects. It is wise, at first, to have an x-ray check-up before the patient is discharged. If the x-ray examination shows that the wire has been satisfactorily placed, the patient may be discharged immediately to resume normal activities with the use of a cut-out shoe. If no pain or temperature occurs, the wire and the sutures may be removed at the same time, in 6 weeks. If pain or swelling occurs, the wound should be inspected, at which time the sutures can be withdrawn. In the series thus far there have been no infections. In four toes there was a slight serous discharge about the wire which was somewhat loose. In 2 of these cases the wire had been permitted to cross the metatarsophalangeal joint, and I think the resultant motion of the wire when the patient walked caused the serous discharge. The wounds rapidly closed as soon as the wires had been withdrawn.

Case 1. J. H., male, aged 35 years, for many years had badly deformed second, third, and fourth hammer-toes on the left foot. Under local anesthesia on January 29, 1940, the procedure described was carried out on the second, third, and fourth toes. Postoperative roentgenograms (Fig. 2) showed satisfactory position of the wires with the exception of the fourth toe in which the wire crossed the metatarsophalangeal joint. The patient was discharged 2 days later and walked about with a cut-out shoe. A month after the operation the sutures were removed, and primary union of all the wounds was noted. Four weeks later the wires were withdrawn. There was slight swelling and serous discharge about the wire in the fourth toe for the reason noted. This rapidly subsided, and the wire openings promptly closed. Roentgenograms

9 weeks after operation (Fig. 3) showed solid bony union, and the patient has had no further disability.

The method has been used on all toes except the great toe and has been found equally efficacious in the correction of congenital hammer-toe deformities.

CASE 2. N. E., female, aged 11½ years, had bilateral hammer-toe deformity of the second toe since birth. Under gas oxygen ether anesthesia the operation described was carried out. Special care was taken to remove a thin layer of cartilage from the proximal end of the middle phalanx to avoid, if possible, interference with the epiphysis (Fig. 4). The wires and sutures were removed 6 weeks later, and x-ray examination revealed union in excellent position (Fig. 5). The correction has been maintained.

Contractures of the distal interphalangeal joints and the metatarsophalangeal joints are usually secondary to the main contracture at the proximal interphalangeal joints and are readily corrected by stretching. Occasionally, if the contracture at the metatarsophalangeal joint requires tenotomy or capsulotomy, this should be carried out. After the correction of the proximal interphalangeal joint and the proper application of the wire, the collodion strip can be extended on to the dorsum of the foot for 2 inches, and this will usually be sufficient to maintain the correction in the metatarsophalangeal joint. Threaded wires were not used because of the smallness of the parts, the occasional need for multiple insertions before the wire is satisfactorily placed, and because there has been no difficulty with wandering (8) of the wires.

The method is simple and direct, but it requires careful attention to detail for its successful use. The danger of infection is apparently more theoretical than real, especially if the wires are satisfactorily inserted so that no movement occurs. Several of my patients who had previous hammer-toes operated upon and splinted by older methods were unanimous in approving of the Kirschner wire immobilization.

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FRACTURES IN THE NECK OF THE FEMUR—ACCURATE SUBCUTANEOUS FIXATION WITH SCREWS

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Philadelphia, Pennsylvania

THERE is no need to enumerate the many advantages of internal fixation for fracture in the neck of the femur, for such treatment has revolutionized the care of this difficult fracture and, as several authors have remarked, "has come to stay." In January, 1939, the Report of the Fracture Committee of the American Academy of Orthopædic Surgeons (1) gave a detailed account of the results in 1485 intracapsular fractures treated by 100 surgeons or their clinics. Union occurred in 89.4 per cent of these cases, and the mortality rate was only 8.5 per cent. Debility and advanced years are indications and not contra-indications for internal fixation, as this type of treatment immobilizes the fracture while the patient's strength is sustained and complications are avoided by activity. Only a short period of hospitalization is necessary and nursing is greatly facilitated.

A majority of surgeons, although realizing the value of this treatment, have experienced considerable trouble and in some instances have had trying ordeals with internal fixation operations. Even upon exposure of the femur and the use of various types of finders and directors with numerous x-ray examinations during the operation the procedure has, as a whole, been difficult and time-consuming. Many surgeons do not attempt internal fixation because they realize these technical difficulties.

INTERNAL FIXATION WITH SCREWS

A number of authors have reported excellent results with two screws which permit firm fixation with coaptation of the fragments. The relative simplicity and security of this form of fixation, first advocated by Martin and later by Brewster (2) and others, have been borne out by our experience with 50 cases. In order to shorten the procedure and to insure greater accuracy, a method has been devised whereby, instead of exposing the femur, these two screws are inserted subcutaneously under anteroposterior visualization with the fluoroscope. The screws are driven in through a very small incision in the lateral aspect of the thigh (4, 5). This simple instrument has proved to be satisfactory in the majority of cases.

Our main difficulty with this form of internal fixation is the lateral placement of the screws, which cannot be visualized with the ordinary fluoroscope. We formerly placed entire dependence upon holding the limb rotated internally while inserting the screws in a horizontal direction. Reliance upon this position in various techniques of "blind" internal fixation explains the failures which have occurred in many cases. Quoting Smith-Petersen himself, "The nail is now driven in, it is kept in the horizontal plane unless the lateral roentgenogram shows that the neck of the femur deviates from this plane; if it does, proper correction is made." This dependence upon internal rotation alone caused failure in several of our cases, as the screws did not cross the line of fracture and protruded outside the neck. The error in these cases was due to two factors which altered the plane of the neck as related to the plane of the table. First, there is a difference in the degree of internal rotation to which every leg can be turned. The second and more important factor is a considerable anatomical variation in the angle at which the neck leaves the shaft as compared to the plane of the patella. Steindler states that according to Mikulicz the torsion of the neck of the femur on the shaft varies, in wide limits, from −20 degrees (posterior twist) to +38 degrees (anterior twist). The anterior twist or anteversion is a common occurrence.

To overcome this difficulty of accurate insertion in the lateral plane, a steel pin and block devised by Dr. Alfred Tuttle, have been added to the original instrument. The pin is thrust along the anterior aspect of the femoral neck, thus guiding the cannula exactly to the central axis in the lateral plane. Since the addition of this guide, the screws have been placed accurately in every case. Advanced age and debility are not contra-indications for this type of fixation, as the technique is rapid and is not shocking and does not require exposure of the femur. The steel screws used are 3, 3½, and 4 inches in length and of 10, 11, and 12 gauge, the size being selected according to the length of the femoral neck. The heads of the

From the Fracture Service, Hahnemann Medical College and Hospital, Philadelphia.

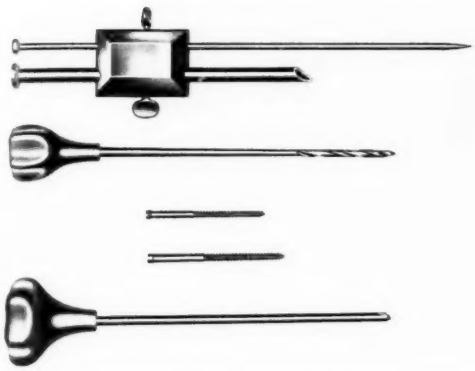


Fig. 1. Instruments for subcutaneous internal fixation. The cannula for insertion of the screws is parallel to and ¾ inch from the pin which guides it to the central axis of the femoral neck. Screws of proper length are selected for the individual case.

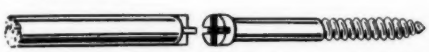


Fig. 1a. Screw of stainless steel with a modified Phillips head, and screw driver to fit.

screws are ¼ inch in diameter and fit accurately in the cannula. Steel screws appear as satisfactory as several we had cast in vitallium, and appear to have caused foreign body reaction or absorption of the bone around them in only 1 case. We attribute the lack of bone absorption to the tightness of this form of fixation. Our observations have been in accordance with those of Brewster (3), who states that he never has found

Fig. 3. In a, left, the angle of torsion in the femoral neck is within the normal limits of between 12 and 25 degrees. In b the angle at the junction of the neck and shaft as compared with the plane of the patella is 40 degrees. Although holding the normal limb, a, in slight internal rotation places the femoral neck in a horizontal plane and any form of fixation inserted in that plane will reach its central axis, depending upon such a position will result in complete failure when pronounced torsion in the neck, b, exists.

Fig. 2. Instrument assembled and placed on the femur. The guide pin is thrust along the anterior surface of the neck until it reaches the head of the femur. As this surface of the neck is nearly flat it can be followed easily. The cannula then is thrust through the soft structures until it reaches the lateral surface of the femur, and being parallel to the pin the screws inserted through it will penetrate the central axis regardless of the angle of torsion in the neck.

it necessary to remove the screws from cases in which union occurred, and he has followed many individuals without any complaints or x-ray evidence of absorption for a period of 10 years.

TECHNIQUE

Our choice of anesthesia is pentothal sodium, administered intravenously. Ether and gaseous

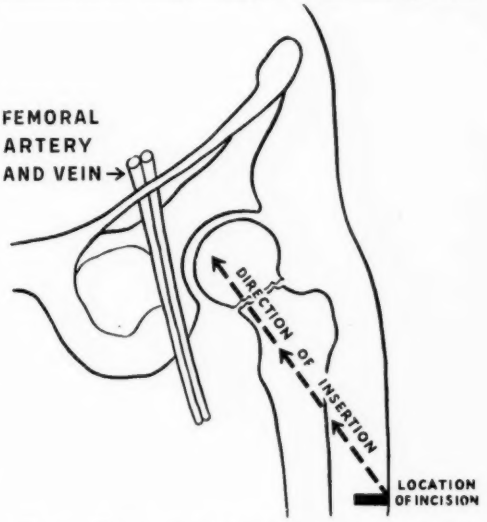


Fig. 4. Diagram of relation of the vessels to the neck and head of the femur. The femoral artery and vein lie 1½ inches to the inner side and 1½ inches anterior to the neck and head. The direction for inserting the first pin and screw is shown by the broken line. Note that the small skin incision is located in a line with the femoral neck, at a considerable distance below the greater trochanter.

Fig. 5. General setup for subcutaneous operation. An assistant holds the limb in moderate internal rotation and abduction, and the knee of the other limb is flexed over the opposite side of the table. A small table with the special instruments, scalpel, and Michel clips is close to the operator. The fluoroscopic screen is over the hip.

agents are avoided on account of the use of the fluoroscope. In the treatment of intracapsular fractures, displacement of the fragments is reduced by the Leadbetter method, and the final position is checked by anteroposterior and lateral roentgenograms. After complete reduction the affected limb is held in wide abduction and internal rotation, the knee of the opposite limb being flexed over the side of the fluoroscopic or fracture table. For this purpose orderlies serve better than doctors, as the latter become interested in watching the technique and may neglect to hold the limbs properly. The patient is protected from the roentgen rays by a 4 millimeter aluminum filter placed over the tube. The surgeon wears a lead-rubber apron, and his hands are absolutely protected by the use of a box covered with ⅛ inch sheet lead, through which the entire operation is performed. The skin is painted and draped, only a small area distal to the greater trochanter being exposed. Then the room is darkened and the site of the incision, which should be on a line with the neck of the femur, is marked on the skin over the lateral surface of the hip. The lights are turned on and a 1½ inch transverse incision through the skin and deep fascia is made, this point being at a considerable distance below the greater trochanter. The sterilized lead box is placed against the hip and the end of the instrument is introduced through the incision. Again the room is darkened and next the guide pin is thrust obliquely through the soft structures to the lateral aspect of the femur in a line with the femoral neck. Then, keeping close to the anterior surface of the neck of the femur, which is relatively flat, the pin is thrust further inward until it touches the head of the femur where it remains firmly fixed. By directing the pin along the neck of the femur under continuous fluoroscopic visualization there is no danger of injury to the femoral vessels, which lie 1½ inches anterior and 1½ inches inward in respect to the neck and head of the femur. The cannula is thrust through the soft tissues, and being parallel to the pin which rests upon the anterior surface of the femoral neck, it points directly to its central axis. The instrument will be in the correct plane regardless of whatever torsion there may be in the neck of any femur. Next, with the aid of the fluoroscope, the drill is inserted through the cannula, and a hole is bored obliquely upward through the outer fragment in a line with the neck. The operator may select the proper length of screws by holding one over the head and neck of the femur under the fluoroscope. It is better to use screws a little too long than too short. A screw is placed in the cannula and is driven across the neck with the special screw driver, the depth and direction of the screw being checked by the intermittent use of the fluoroscope. Then the guide pin is partially withdrawn and is replaced ½ or ¾ inch above the first location and parallel to it on the neck of the femur, and the second screw is inserted through the accompanying cannula in a similar manner. Finally the hip is roentgenographed in both the anteroposterior and lateral planes in order to check the exact position of the screws. If the films show that the screws are placed a little too

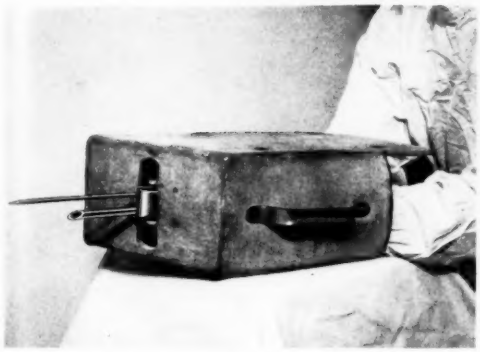


Fig. 6. Lead covered box for protection of the operator's hands. The instruments are manipulated through the slot. A rectangular piece of lead-rubber clipped to the side of the hip may be used instead of the lead box.

deep or not quite deep enough, they may be adjusted at this time. The instrument now is withdrawn, and the skin incision is closed with two or three Michel clips. This method requires an average time of 23 minutes.

POSTOPERATIVE CARE

No shock and very little pain follow this procedure. Neither splinting nor traction is used. Careful attention is given to the patient's general condition and immediate function is encouraged. Occasionally the surgeon must move the hip and knee in order to convince the patient that he has control of it, and then frequent exercises are ordered. In most instances the patient is helped to sit over the side of the bed on the first day after operation, although in debilitated individuals it has been found best to wait and only use a backrest for a few days. After confidence has been restored by turning and sitting on the side of the bed the patient is further encouraged to slide over the side of the bed and to stand beside it without aid, touching only the foot of the affected limb to the floor. After thus learning to balance properly the use of crutches is relatively easy. It is not advisable under any circumstances to stand the patient up on crutches without these preliminaries. The use of a wheel chair is avoided, as this promotes inactivity. Weight-bearing without crutches is not permitted until periodic x-ray examination shows union. It should be remembered that fractures occurring in the femur always unite endosteally, without any evidence being shown of external callus, and that bone trabeculation is the only definite proof that union has been accomplished.

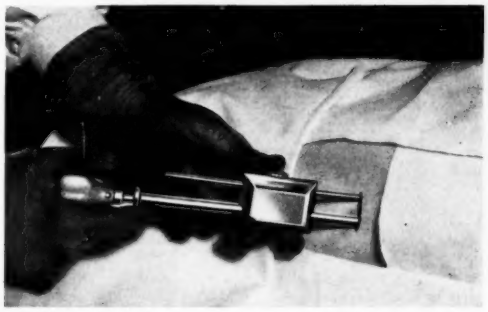


Fig. 7. The guide pin has been inserted over the anterior surface of the femoral neck, and a hole is being drilled through the outer fragment. The lead covered box is omitted for the photograph.

RESULTS

There were 50 cases in this series. The average age was 73 years. The average hospitalization period was 24 days. The average time required for operation was 23 minutes. Operative infection occurred in no case. There were no operative deaths. There were 3 operative failures.[1] Re-operation (re-insertion of screws)[2] was necessary in 2 cases. Screws were removed[3] in 2 cases.

[1] In one case the screws were too short to reach the subcapital fragment. In another case there evidently was a decided anteversion of the neck and the operator failed to insert the screws across the fragments. In the third case in which there was non-union and displacement for 15 months after the injury, the fragments could not be reduced by manipulation. An attempt to hold this fracture by inserting the screws in various directions failed.

[2] Re-insertion was successful.

[3] In 1 case there was a small sinus and absorption of the bone around the screws, although at operation 13 months after the internal fixation there was firm union without deformity. In the other case there was persistent pain, operation was permitted only for removal of screws.

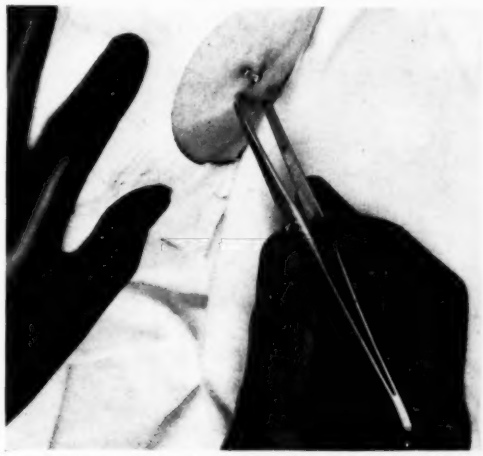
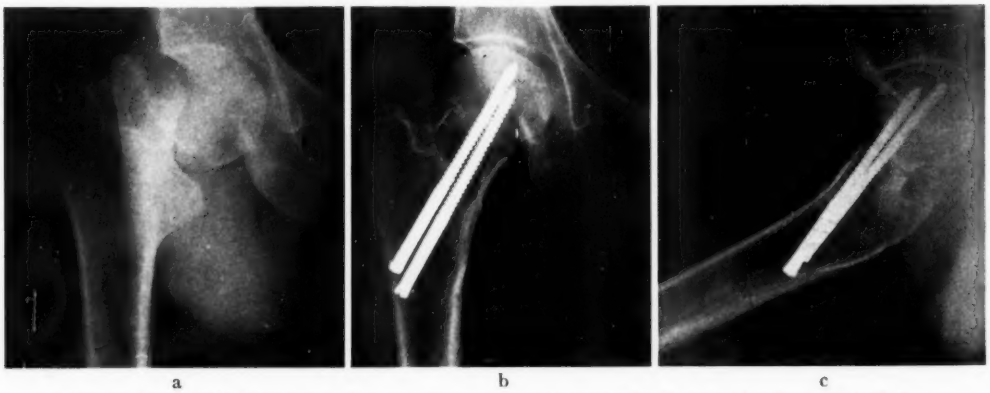


Fig. 8. The wound is closed with 2 or 3 Michel clips.

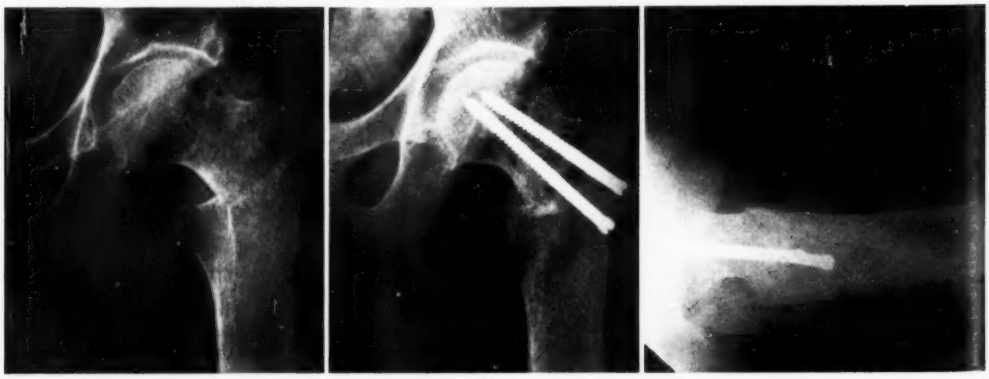
a b c

Fig. 9. Transcervical fracture. a, Before treatment; b, anteroposterior film after fixation; c, lateral view.



a b c

Fig. 10. Transcervical fracture. a, Before treatment; b, anteroposterior film after fixation; c, lateral view.



a b c

Fig. 11. Fracture at the base of the neck. a, Before treatment; b, anteroposterior film after fixation; c, lateral view.

Non-union[1] occurred in no case. The first patient was operated upon in October, 1936. Union has occurred in all of the cases which have been followed, except those which were ununited when the screws were inserted. Several debilitated patients died within a few weeks after operation and before discharge, but not as the result of the operation. A number of the entire series died a few months later on account of heart failure, diabetes, dementia, and embolism.

SUMMARY

An accurate technique of internal fixation which is satisfactory for all fractures in the neck of the femur has been described. It is safe and requires only a short time. The steel screws used have not caused foreign body reaction, and are inexpensive. Our experience with this method has proved its value.

[1] In 1 of these cases non-union had been present 6 months and in another for 15 months before these operations were performed. The procedure was of no benefit in either case.

The instrument described was perfected with the co-operation of George P. Pilling and Son Company, Philadelphia.

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URETERO-INTESTINAL ANASTOMOSIS AND CYSTECTOMY

TRANSPLANTATION of the ureters into the sigmoid with cystectomy has been established as a sound surgical procedure in recent years. Before the introduction of intravenous urography, the general opinion was that dilatation of the ureters and consequent renal sepsis invariably occurred following this operation. These deductions were based upon a very small number of cases in which examination was made after death from diverse causes and at varying intervals after the operation, and they have been proved unwarranted by more extensive investigations. By modern roentgenographic technique, it can be demonstrated that the ureters and kidneys remain normal or nearly so for a period of years, when the operation has been performed with proper care.

Ureterosigmoidal anastomosis is accepted as the procedure of choice for the relief of extrophy of the bladder in children, but there is some difference of opinion among surgeons as to the age at which the operation should be performed. In the past, the consensus was that the operation should be postponed until the child was four or five years of age, despite the fact, established by numerous observers, that the ureters may become dilated and the child may succumb to renal sepsis before this age is attained. In the last two or three years, it has been demonstrated that the ureters may be implanted into the bowel of infants less than one year of age with a surprisingly low mortality, and with satisfactory end-results. The procedure has been tolerated well, and it has been accomplished without complications from renal infection, because, in very young children, the bacteria in the intestines are less virulent and less abundant than in older children.

In a few children with epispadias the structural defect is so extensive that the sphincters are involved, and even though the continuity of the urethra is established, incontinence persists. If plastic operations fail to correct the incontinence, diversion of the urine into the bowel is justifiable to eliminate the constant soiling of the clothing with urine and to make the patient comfortable.

The majority of women with vesicovaginal fistula may be cured by plastic procedures, but occasionally operations of this type are contra-indicated because of the extent of the defect, or because of replacement of normal tissue by scar tissue following unsuccessful surgical treatment previously. In carefully selected cases of this type, ureterosigmoidal transplantation affords complete relief.

In some instances when nephrectomy is performed for renal tuberculosis and in rare cases of Hunner ulcer, the patient fails to

respond to conservative therapeutic measures, and suffers intolerable pain, accompanied by diurnal and nocturnal frequency, and pronounced dysuria. These symptoms may be completely relieved by diversion of the urinary stream into the bowel, leaving the bladder intact.

The value of cystectomy and transplantation of the ureters into the bowel in selected cases of carcinoma of the bladder has been the subject of considerable discussion and controversy in recent years. While there is but little doubt that complete cystectomy is the preferred operation in the management of certain cases of vesical carcinoma, the indications for the operation are still debatable. In the past, this operation was advocated only when extensive invasion of the bladder had taken place, with considerable dilatation of the ureters. The transplantation of such ureters is bound to be accompanied by a high rate of mortality. Hence the procedure of choice in this type of case is cutaneous ureterostomy and cystectomy.

There is a group of cases of carcinoma, however, in which cystectomy and transplantation of the ureters should receive serious attention. When the new-growth is situated at the base of the bladder and the ureteral orifices are encroached upon or the vesical sphincter is invaded, when extensive multiple or single infiltrating tumors are present, or when multiple recurring tumors develop rapidly and cannot be controlled by fulguration, the radical operation should be considered. Before advising this operation, however, certain other factors must be carefully appraised. Renal function must be adequate, preferably in both kidneys; at least it must be approximately normal in one kidney. Intravenous urography should demonstrate that the caliber of the ureters is such that their transplantation into the bowel is technically feasible. There should be no evidence of acute or subacute pyelonephritis. A biopsy should be secured to determine the degree of malignancy of the lesion before the cystectomy is performed. If there is evidence of metastasis or extension of the tumor beyond the confines of the bladder, there is no possibility of a cure, and the patient should not be subjected to the radical procedure.

No phase of the treatment is more important than the preparation of the patient before operation. As a general rule, four to six days are required to cleanse the bowel, to improve renal function, and to control renal infection.

Numerous individual operative techniques have been presented in the literature. As a rule, however, the original submucous technique of implanting the ureter into the bowel, or one of a number of modifications, is employed. Simplicity is the criterion of any satisfactory operation; the more complicated the procedure, the higher the operative mortality. In addition, the operative technique should include rigid attention to asepsis, lack of tension at the site of the anastomosis, absence of obstruction and kinking of the ureter, and immobilization of the bowel. The decision as to whether unilateral or simultaneous bilateral transplantation should be performed is influenced by the general condition of the patient, the caliber of the ureters, the condition of renal function, and the presence or absence of renal infection as well as the personal experience of the surgeon. Although in many instances unilateral transplantation of the ureter is advisable, bilateral transplantation in well selected cases can be performed with equally successful results.

When the unilateral procedure is chosen, the operation may be performed in two or three stages; that is, by transplanting the ureters singly, and finally removing the bladder, or by

performing the cystectomy at the time the second ureter is transplanted into the bowel. If simultaneous transplantation is performed, the bladder may be removed two weeks later. When the transfixion suture technique is employed, both ureters may be transplanted simultaneously, as there is no interruption in the urinary stream to the bladder until after the new channel into the bowel has been established.

When the cases are wisely selected, and the technique carefully carried out, ureterosigmoidal anastomosis is a valuable, and at times, a life-saving measure. The patient is comfortable; the rectum serves well as a reservoir for the urine, and a natural sphincter, under voluntary control, eliminates soiling of the clothing. He is able to resume normal life and activities and even to return to a gainful occupation. It cannot be stressed too strongly that the results to be obtained from ureterosigmoidal transplantation depend, perhaps more than in any other field of surgery, upon the individualization and proper selection of cases. CHARLES C. HIGGINS.

CLINICAL INVESTIGATION

A RECENT editorial in one of our most widely read journals called attention to the importance of clinical investigation. Harvey Cushing, in his address before the Seventeenth International Congress of Medicine in London in 1913, said, "Nature is loath to give up her secrets; discoveries do not come by chance; they are made by those only who are industriously prepared to observe them." He realized that clinical investigation was important for he once said "Let us not forget that investigation at the bedside is just as important as investigation in the purely experimental workshop." Cushing's concept of clinical investigation was work carefully planned, rigidly controlled, and skilfully executed; free from bias and statistically sound. Good clinical investigation is often far more difficult than animal investigation and much of it is an extension of work begun in a laboratory of the fundamental sciences.

Clinical investigation should, wherever possible, be done under conditions which permit of the most rigid type of control and much of it should be done by men who have had some preparation in the field of investigation. I find myself in agreement with Cutler, who, in speaking of training in a good experimental laboratory, found that this involves training in "accurate observations, logical deduction and the bringing forth of conclusions based on fact. It tends to do away with conjecture, ideas based on supposition, hearsay and single isolated observations." The statement that "the physician cannot always wait until the fundamental discoveries have been established beyond a shadow of doubt in the laboratory," is beyond question; but the physician can wait until he has proof beyond reasonable doubt on the basis of carefully made clinical experiments, before publication of his clinical observations. Hasty publication based on too few data, or on data not carefully compiled and studied, has resulted in the temporary widespread adoption of many methods of therapy which were finally proved to be worthless.

There is now general agreement that surgical competence is hardly to be considered in the widely divergent data on mortality of operations for perforated ulcer, the acutely inflamed gall bladder, and acute appendicitis with peritonitis. Elliott Cutler once said, "The explanations for our surgical failures are to be found in the bacteriological and physiological laboratories more frequently than in the anatomical rooms."

If Roscoe Graham is correct, and I believe he is, that, in the treatment of perforation of a

gastric or duodenal ulcer, the surgeon's sole function is to save life, Junghanns cannot be correct when he advocates subtotal resection of the stomach in the presence of a grossly contaminated peritoneum. Recent controversial articles upon whether the acute inflamed gall bladder should be treated by "skilful neglect," immediate cholecystostomy or immediate cholecystectomy, frequently fail to point out the changing pathologic characteristics of the process over a period of hours, a factor that should cause the operator to vary the procedure depending upon what is exposed during the operation. The statement frequently made that the acutely inflamed gall bladder should be treated like the acutely inflamed appendix demonstrates a lack of consideration of the sequelæ of these two processes. The apparent widespread disparity in mortality in good surgical clinics following operations for acute appendicitis associated with peritonitis cannot be due entirely to differences in the incision, anesthesia, and other factors under control of the surgeon. In very few of the papers that have been published are the data on the extent of the peritonitis of real significance. The use of the term "generalized peritonitis" in clinical writing should be condemned. This is an autopsy diagnosis and the surgeon who attempts to determine the extent of the infection during the operation is playing with the life of the patient. Some surgeons record the patient as having peritonitis only when a positive culture is obtained from the fluid present in the peritoneal cavity at operation, and others when a turbid fluid, which consists almost entirely of leucocytes and histiocytes, is present.

Laboratory investigation which has been carefully planned and carefully executed can be repeated by the same methods, by the same controls, in the same or other laboratories. We have a right to demand similar criteria for clinical investigation. There is no need to separate the clinician and the investigator. There is every reason to bring them together. In this sense every well qualified practitioner should be inquisitive and if he is, he will find much to observe and investigate. If he develops the scientific method of accurate observation, he will correlate his findings and be more likely to draw sound deductions.

I. S. Ravdin.

TEXTS AND DOCUMENTS

REPORT OF THE AUTOPSY OF THE SIAMESE TWINS TOGETHER WITH OTHER INTERESTING INFORMATION COVERING THEIR LIFE[1]

A Sketch of the Life of Chang and Eng

ARNO B. LUCKHARDT, M.D., Chicago, Illinois

THOUGH many of us refer rather glibly to the original Siamese twins, few of us are old enough to recall the time when these two gentlemen created a medical and public sensation in this country some 67 years ago. It is, furthermore, fair to state that few pathologists, here or abroad, are or ever have been familiar with the interesting necropsy report on these twins by very capable men, and certain aspects of their life in conjunction with the autopsy findings have a particularly important bearing on the interpretation of data collected by those physiologists and experimental pathologists who by surgical methods attempt to produce experimental parabiotic twins in studies of avitaminoses or endocrinology; for although the original Siamese twins had a common liver "the parenchymatous tissue being seemingly continuous between them," the one twin, Eng, was not affected when the other, Chang, was intoxicated, which was rather frequent; neither did the sickness of one ever affect the other, nor did the bilious attacks common to both affect the brothers simultaneously. Most of this would seem to indicate "that there was no free interchange in their circulations." The probability that the twins arose from a single ovum raises a theological question as to whether the twins had one or two souls, etc., since according to some theologies a single soul is implanted at the time of conception. This same question, of course, can be raised in connection with the souls of all identical twins. The sociological aspects of the life of such twins will occur naturally to the reader.

The text of the report published in 1874 now follows:—

IN the present article it is not purposed to give an elaborate history of these famous twins, but only to put on record certain well-ascertained facts of physiological interest in regard to their life, to give all that can be ascertained as to the circumstances of their death, and to offer a brief history of the manner in which their bodies were brought to Philadelphia.

According to a writer in *Lippincott's Magazine* for March, the Siamese Twins were born in 1811, some thirty miles southwest of Bangkok; their father being a Chinaman, their mother a native of Siam, bred by a Chinese father. The twins were, therefore, three-fourths Chinese, and were known in their native home as the "*Chinese* Twins." They were the first-born sons of their parents: but their mother has presented her husband with four other pairs of twins and four children born at single births—all of them normal and healthy. Their mother, during their infancy, entirely recognized their separate individuality, and also the fact that there existed a common sensibility in the centre of the band. She stated, what is undoubtedly true, that at first the ligament was so short that the boys were compelled always to be face to face; even in the bed they could not turn without being lifted up and placed in the desired position. As they grew, the ligament seemed gradually to stretch, until they were able to stand side by side, and even back to back, and to turn themselves in bed by rolling one over the other. The father being a fisherman of the laboring class, the boys lived in one of the floating houses of the country, and soon became famous swimmers, spending much of their time in the river. It was the peculiarity of their movements in the water

[1]Reprinted from the Philadelphia Medical Times. Philadelphia: J. B. Lippincott & Co. 1874. 39 pp. with 3 illustrations.

which first attracted the attention of a Scotch merchant, Mr. Robert Hunter, and finally led to their leaving their native country in quest of fortune.

For many years Chang and Eng Bunker lived in North Carolina, where they were married, and raised large families of children, Chang being the father of ten, Eng of nine. Dr. Joseph Hollingsworth, to whom we are indebted for the information given in this article as to their habits of life and the circumstances of their death, states that he had known them as residents in the neighborhood of Mount Airy, North Carolina, for some twenty years, during which time he had acted as their family physician. Chang, who is said to have derived his name from the Siamese word for "left," was the left of the pair, and was much smaller and more feeble than his brother Eng, whose name signifies "right." Their habits were very active: during the latter part of their life they and their families lived in two houses, about a mile and a half apart, and it was an inflexible rule that they should pass three days alternately at each house. So determinedly was this alternation maintained that sickness and death in one family had no effect upon the movements of the father, and a dying or dead child was on one occasion left in obedience to it: indeed, Dr. Hollingsworth is very positively of the opinion that the death of the twins themselves was the result of this rule, or, at least, was materially hastened thereby. This will be made apparent hereafter.

The evidences during life that the twins were physiologically distinct entities were very numerous and apparent. They were different in form, tastes, and disposition; all their physical functions were performed separately and unconnectedly. What Chang liked to eat, Eng detested. Eng was very good-natured, Chang cross and irritable. The sickness of one had no effect upon the other, so that while one would be suffering from fever the pulse of the other would beat at its natural rate. The twins not rarely suffered from bilious attacks, but one never suffered at the same time as the other; a circumstance which seems somewhat singular in view of the close connection which the postmortem has shown to exist between the livers of the pair. Chang drank pretty heavily—at times getting drunk; but Eng never felt any influence from the debauch of his brother—a seemingly conclusive proof that there was no free interchange in their circulations.

The twins often quarrelled; and of course, under the circumstances, their quarrels were bitter. They sometimes came to blows, and on one occasion came under the jurisdiction of the courts. After one of these difficulties Chang and Eng applied to Dr. Hollingsworth to separate them, stating that they could not live longer together. Eng affirmed that Chang was so bad that he could live no longer with him; and Chang stated that he was satisfied to be separated, only asking that he be given an equal chance with his brother, and that the band be cut exactly in the middle. But as Dr. Hollingsworth advised very decidedly against this, and declined to interfere, cooler counsels prevailed upon the twins to remain as they were.

In August, 1870, Chang suffered from a paralytic stroke, from which he never fully recovered; and during the last year of his life he several times said to Dr. Hollingsworth, "*We* can't live long."

On the Thursday evening preceding their death, the time having arrived for their departure from the house at which they were staying, the twins rode a mile and a half in an open wagon. The weather was very cold—the night being the severest of the winter. Chang had been complaining for some days of cough, with distress and actual pain in the chest. He was so unwell that his wife thought he would be unable to bear the trip; but he finally went. On Friday morning Chang reported that he felt better, but that in the night he had had such severe pain in the chest, and so much distress, that he thought he should have died.

The twins slept in a room by themselves or with only a very young child present; and some time in the course of Friday night they got up and sat by the fire. As they were accustomed to do this frequently, nothing was thought of it by those of the family who saw them, even though they heard Eng saying he was sleepy and wanted to retire, and Chang insisting on remaining up, stating that his breathing was so bad that it would kill him to lie down. Finally, however, the couple went to bed again, and after an hour or so the family heard someone call. No one went to the twins for some time, and, when they did go, Chang was dead, and Eng was awake. He told his wife that he was very "bad off" and could not live. He complained of agonizing pain and distress especially in his limbs. His surface was covered with a cold sweat. At his request his wife and children rubbed his legs and arms, and pulled and stretched them forcibly. This was steadily continued until he went into a stupor, which took place about an hour after the family were alarmed. The stupor continued up to death: according to the statements of the family, there were no convulsions.

Dr. Hollingsworth did not reach the house until after the death of both of the twins. He found the wives, and especially the children, averse to any postmortem being made, but, after much persuasion, obtained permission to put the bodies in a position to be preserved until he could obtain someone from Philadelphia to perform the autopsy. He placed the bodies, after they had been thoroughly cooled, in a coffin, which was put in a wooden box, which was, in its turn, enclosed in tin; the whole being buried in a dry cellar in such a way as to be imbedded in charcoal.

As bearing upon the question, What was the cause of the death of Chang? it is important to state that Dr. Hollingsworth had repeatedly told Chang and Eng that, in his opinion, the death of one did not necessarily compromise the life of the other; that he could separate them, by cutting close to the body of the dead one, without killing the living one. It would appear possible, in view of this, that the death of Eng was not simply the result of fright.

Shortly after the death of the Siamese Twins, Dr. William Pancoast requested the Mayor of Philadelphia to telegraph to the Mayor of Greensboro', North Carolina, in regard to the possibility of a postmortem examination being obtained. To this the Mayor of Greensboro' substantially replied that he had neither knowledge nor power in the matter. When Dr. Hollingsworth, *en route* North, arrived at Greensboro', the telegram of Dr. Pancoast was handed to him. On the evening of his arrival at Philadelphia (Friday) he saw Dr. Pancoast and Prof. Gross, and a letter was written to the wives of the twins, proposing that Dr. Pancoast should come on to embalm and examine the bodies.

On Sunday Dr. Hollingsworth saw Prof. John Neill and, on consultation, it was concluded that the matter was of public importance, and should not be confined to any single private individual. As the promptest method, it was deemed best to call a meeting of such physicians as were interested in the matter and could be hastily got together.

The meeting took place on the evening of Monday, January 26, 1874, at the house of Dr. Neill; but, although a number had been asked, only Prof. Leidy and Dr. Ruschenberger, besides Drs. Hollingsworth and Neill, were present at the conference. As the result of their deliberations, it was determined that two gentlemen should be at once dispatched to the home of the twins, in order to examine and embalm the bodies as speedily as possible; and it was agreed that Drs. William H. Pancoast and Harrison Allen should be requested to go.

It will be seen at once that the College of Physicians was in no wise responsible for the acts of the Commission, although its name was freely used by the prominent Fellows engaged in the transaction. Indeed, these gentlemen, recognizing this, were prepared to meet the expenses of the trip had the College failed to endorse their action.

Owing to various obstacles and embarrassments, the Commission did not leave the city until Thursday night, January 29. At the request of Dr. Pancoast, Dr. Andrews went with the party as a companion and aid.

The Commission arrived at Mt. Airy on the evening of Saturday, January 31, and proceeded to the residence of Eng the following morning, in company with a photographer and Dr. William Hollingsworth, who is the family physician in the absence of Dr. Joseph Hollingsworth. The widows of the twins received the Commission hospitably, and a conference was at once entered into, at which the "Mistresses" Bunker, the Commission, Dr. Hollingsworth, and the widows' legal adviser were present. It was then agreed that, under consideration of embalming the bodies of the twins, permission would be granted to exhume and examine the structures distinguishing them, provided that no incision should be made which would impair the external surface of the band. Subsequently it was agreed that limited incisions would be allowed on the posterior surface of the band. An agreement in writing was then drawn up, expressing the above restrictions, but extending the authority to the Commission to remove the bodies to Philadelphia, provided that they be kept in a fireproof building and held subject to the commands of the families when informed of the completion of the embalming process.

The object of the visit of the Commission, having been noised about the country had attracted a crowd of curious people, who were willing enough to give the necessary aid in exhuming the bodies. The circumstances attending this were briefly as follows. The bodies were buried in the cellar of Eng's house, in a shallow grave, which had been covered with a tumulus of powdered charcoal. This being removed revealed several planks covering an outer wooden box, which, in turn, enclosed a tin encasement to the coffin. After unsoldering the tin box, the coffin was unscrewed, and the object of the search was exposed to view. It was certainly an anxious moment. Fifteen days had elapsed since death, and no preservative had been employed. It was an agreeable surprise, therefore, that no odor of

decomposition escaped into the room, and that the features gave no evidence of impending decay. On the contrary, the face of Eng was that of one sleeping; and the only unfavorable appearance in Chang was a slight lividity of the lips and a purplish discoloration about the ears. The widows at this point entered the room, and, amid the respectful silence of all present, took a last look at the remains.

The room was then cleared of all not connected with the work of the Commission; the bodies were disrobed, and preparations at once begun to secure photographs. The bodies were held in an erect position, and negatives of the entire figures, and views of the band at short foci, were secured. The day being cloudy, much time was necessarily expended in obtaining these pictures—time sufficient for a number of observations upon the external appearance of the bodies to be recorded. The notes are given just as they were taken at the time:

Examination made Sunday, February 1, 1874, fifteen days and eight hours after the death of Chang.

The bodies were found in the coffin in a good state of preservation; there was a slight cadaveric odor about Chang, with marked passive congestion of the back of the arms and neck on both sides, and in a less degree of the posterior aspect of the forearms, buttocks, thighs, and legs; there was none on the feet, where, however, there was marked fulness of the superficial veins; this was better marked on the left side. There was a greenish discoloration on the anterior abdominal wall.

Face.—Lips moist and discolored; peculiar reddish congestion sparsely distributed over malar prominence and beneath ear. The thoracic discoloration was much deeper on the side next to Eng.

The left nipple was visible in front well towards the middle line, the right one just showing. The fingers of the right hand—the paralyzed side—were forcibly flexed, although *rigor mortis* was absent.

In Eng there was passive congestion of back, most marked on buttocks and infra-spinous spaces—none on the front of the body; slight greenish discoloration of anterior abdominal wall.

In both subjects the hair of the head was gray.

On *the pubis* of each subject the hair of the *left side* was *gray*, that of the *right side*, *black*.

The process of embalming was now begun. Incisions were made to the outer side of the median line of the abdomen in each individual, extending from the inferior margin of the thorax to a point midway between the symphysis pubis and the anterior spinous process of the ilium. The aorta was reached after the usual method, but was found to be in an atheromatous condition, compelling the selection of the left primitive iliac for the insertion of the pipe. A solution of chloride of zinc was then injected.

After the embalmment had been completed, the incision was continued upward and inward towards the band. Examination of the band through this incision convinced the Commission of the complex nature of the band, and suggested the suspension of a complete study of the parts until removal of the bodies to Philadelphia. The fact that the photographs had been far from satisfactory strengthened the Commission in its decision to stop the investigation at this stage. The incisions were, therefore, sewn up, the clothing readjusted, and the bodies placed in the coffin and conveyed to Mt. Airy. Here the tin box which was used for the temporary burial was again brought into use, and the lid carefully resoldered. Without delay the Commission started on its return to Philadelphia, expressing the bodies at Salem.

The Commission arrived in Philadelphia, February 5, having been absent one week.

Upon the arrival of the bodies at the College of Physicians, they were placed in the care of the committee upon the Mütter Museum and of the Hall Committee, and were closely locked and guarded until a special meeting of the College was called, upon Monday evening, February 8, when, after considerable discussion, it was agreed that the College should accept the action of its Fellows and pay the expenses of the trip. Further, a vote of thanks was given to the gentlemen who went to North Carolina, and to Dr. Hollingsworth, and the Mütter Committee was authorized to appropriate three hundred and fifty dollars for the preparation of casts and photographs, which should remain the property of the Museum. Finally, the College appointed the Mütter Museum Committee and the original Commission (Drs. Pancoast and Allen) as a joint committee for carrying out the examination of the Siamese Twins; it being understood that a report and a demonstration of the specimens were to be made to a subsequent meeting of the College; also, that the dissections and the report were to be the work of the original Commission.

On Tuesday, the 10th instant, they were exposed for study: they were at that time found in a satisfactory condition, except the right lower extremity of Chang, which required immediate care to prevent further destructive changes taking place.

STATEMENT

Statement of Eng's widow, made to the Commission at Mount Airy.—The paralytic stroke from which Chang had suffered occurred about three years ago, when he was at sea, seven days out from Liverpool. He had been intemperate for some time previously, and had been drinking hard on board the vessel, being frequently intoxicated. He had never had mania à potu. Even when he was drunk, Eng was not affected. Two of his children had died; one from phthisis, the other apparently from apoplexy. Eng had lost five children: one each from phthisis, diphtheria, and dysentery, one from the effects of a burn, and one still-born.

Chang died Saturday, January 17. He had had a cough since the preceding Monday night. It was dry, with scanty, frothy sputum and no pain. Left lung probably involved; slight dullness on corresponding side. On Thursday, January 15, his skin was acting freely, and for that reason Dr. Hollingsworth ordered him not to venture out; but in spite of that prohibition, he went as usual to Eng's. At the time of his arrival he had little cough and no expectoration, but loud bronchial râles were plainly heard by those around him.

When Eng saw his wife after learning that Chang was dead, he said, "I am dying," but did not speak of his brother's death. He soon afterwards expressed a desire to defecate, and this continued for half an hour. He rubbed his upper extremities, raised them restlessly, and complained of a choking sensation. The only notice he took of Chang was to move him nearer. His last words were, "May the Lord have mercy on my soul!"

PHONOGRAPHIC REPORT— THE SIAMESE TWINS AT THE COLLEGE OF PHYSICIANS

A special meeting of the College of Physicians of Philadelphia was held at the hall, Wednesday evening, February 18, for the purpose of hearing the report of the Commission on the Siamese Twins,—Dr. W. S. W. Ruschenberger, U.S.N., in the chair. On the motion of Dr. Gross, it was, after some discussion, resolved that the *Philadelphia Medical Times* be allowed to report the proceedings of the meeting, on condition that three hundred copies of the journal should be given to the college for the use of the members.

The bodies of the Siamese Twins being upon the table, the meeting proceeded to hear the report of Drs. Pancoast and Allen. On behalf of the Commission, Dr. Pancoast stated that, the dissection not having been entirely completed, their report would be a verbal one, to be followed at some later date by a memoir upon the subject. He further remarked that it had been agreed that he should consider chiefly the surgical aspect of the matter in hand, whilst to his colleague had been assigned the demonstration of the anatomical peculiarities.

DR. WILLIAM H. PANCOAST:

Mr. Chairman, and Fellows of the College:—Having been requested, as a member of the Commission, to open the discussion this evening, I will say briefly, in reference to this monster of a symmetrical duplex development, joined, as many of the Fellows now know, at the ensiform appendix and also here at the omphalos or navel, that at the investigation which we made on the first occasion at Mount Airy I made the opening incision of the body on the line for the ligation of the primitive iliac, on the right side; Dr. Allen made the incision on the left. The object was to reach the great vessels,—the aorta and the two primitive iliacs,—and to force the injecting material which we used for embalming (chloride of zinc) up the aorta and down the iliacs until it ran from the incisions made in the fingers and toes. It flowed freely through the blood-vessels in Eng, owing to the ossified condition of his arteries; the injection in Chang was, however, not so successful, owing to decomposition in the tissues and blood-vessels. It was necessary to repeat the injecting process several times in order to preserve the body. The arteries of Chang were found to be very much decomposed,—quite rotten, in fact.

In Dunglison's *Medical Dictionary* we find the scientific name given for the Siamese Twins, in the classification of teratology, to be *Xiphopages;* and by referring to the admirable article on Diploteratology of Dr. G. J. Fisher (published in the Transactions of the Medical Society of the State of New York for the year 1866), it will be found that the twins belong in the class of *Anacatadidyma.* In his classification of double monsters he makes three orders: *Order first,—Teratacatadidyma;* derived from *teras, teratos,* a "monster," *kata,* "down," and *didumos,* a "twin." *Definition,*—duplicity, with more or less separation, of the cerebro-spinal axis, from above downwards. *Order second,—Terata-anadidyma,* derived from *ana,* "up" or "above," and *didumos,* a "twin." *Definition,*—duplicity, with more or less separation, of the cerebrospinal axis, from below upwards, or from the caudal towards the cephalic extremity of the neural axis. *Order third,*—Terata-*anacatadidyma,* derived from *ana,* "above," *kata,* "down," and *didumos,* a "twin." *Definition,*—duplicity, with more or less separation, of both the cephalic and the caudal extremity of the cerebro-spinal axis, existing contemporaneously. In this order, the monster now before us might be called an *Omphaloxiphodidymus.*

Thus we have the scientific nomenclature of this monster. Of course, the consideration of the greatest interest to the profession, and one of the main reasons why the Commission made such exertions to obtain this post-mortem, was that the American profession might not be charged with having neglected an effort to obtain an autopsy, which would solve the mystery of their union. The feature of greatest interest is connected with this band,—about four inches long and eight inches in circumference. In addition to this, there are other points of importance in teratology, in regard to the fulfilment of the law of homologous union, in relation to the juncture of the recti muscles and the fasciæ of the obliquus and transversalis at their point of meeting in the centre of the band in regard to the position

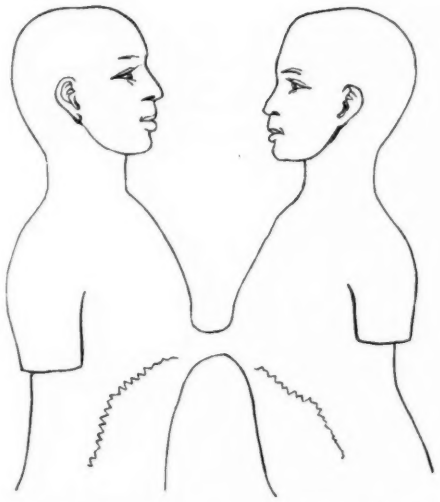

Fig. 1. Diagram from a cast showing the position of the ligament and of the primary anterior incisions. During life the twins never assumed the face-to-face position in which they are here represented and which is without doubt that of their fœtal life.

of the hearts, we think their apices present towards each other. [This has since been found to be the case.] The livers we have found to approximate to each other and to push through the respective peritoneal openings into the band. We extended our incisions to the margin of the band in front. By placing my hand in the peritoneal cavity of Eng and my colleague placing his hand in the peritoneal cavity of Chang, we pushed before us processes of peritoneum, which ran on to the median line of the band; and we could feel our fingers in the lower portion of the band, behind the median line, with a distinct layer of peritoneum between them, demonstrating at once the prolongation of the peritoneum into the band, and the complete separation of one peritoneal cavity from the other at this median line. Above that we felt some traces of vascular connection, apparently running from one liver to the other; but this we will examine into when we have a better opportunity of carefully dissecting and examining what vascular structures may exist. We also noticed that in turning off the flaps consisting of the anterior walls of the abdomen, the hypogastric arteries, as illustrated by the diagram on the blackboard, ran upwards in each body into the band. We lost them in this way, as we think, towards the common umbilicus in the anterior inferior surface of the middle of the band.

It is probable that the two hypogastric arteries on each side passed through this umbilicus. Whether or not there were two umbilical veins, we have not yet been able to decide, nor to answer the question whether the umbilical cord was double or single and composed of the four hypogastric arteries and two umbilical veins, or whether the placenta was single, double, or twin.

We also recognized that the ensiform appendix, as shown in the diagram of each side, was prolonged and united in the middle line. On our later examination, we find that there is complete continuity of structure of the cartilages,

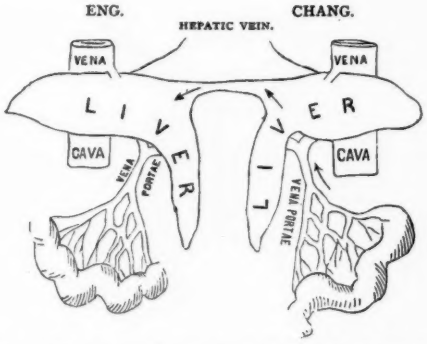

Fig. 2. Diagrammatic representation of the livers, portraying the relations of the vessels, etc. The arrows show the directions in which the injection passed from Chang to Eng.

but no true joint at the middle line, although it is possible there may be some small synovial sacs farther up. The motion is mainly due, as I here demonstrate to you by moving these bodies one upon the other, to the elasticity of the connected ensiform appendices and intervening fibro-cartilages.

In regard to the vascular connection of the band, we have not yet been able to make so thorough and careful an examination as we wished; but still, in throwing colored plaster into the portal circulation of Chang it has been found to flow through the vessels of the upper part of the band into the portal vessels of Eng. So that the surgical anatomy of the band consists in the skin and fascia which cover it, the two separate peritoneal pouches which meet in the middle, the large peritoneal pouch, the vascular connection, to whatever extent that may exist between the two portal circulations, and the remains of the hypogastric arteries in the lower portion of the band. Thus the main difficulty in any operation for section of the band would seem to be in regard to the peritoneal processes and the portal circulation. The anastomosis which may exist between the internal mammary arteries and the intercostals in the integument in the upper portion of the band, of course would present no difficulty.

I will not venture upon any further remarks as to the surgery of the case, while there are so many distinguished gentlemen present more competent than myself to give an opinion. At the same time, operations on the peritoneum may not be considered so hazardous in this day, when ovariotomy, gastrotomy, and even Cæsarian section, are so often performed. The peritoneum-pouches themselves would not present so great a difficulty as might be anticipated, under pressure and acupuncture, by which the sensitiveness of the structure might be so altered as to permit of a section. I was informed at Mount Airy that in Paris a surgeon had made the experiment of applying pressure upon the band, and it was reported the twins had fainted in consequence. I could not ascertain, however, whether this was from fright, design, or actual pain.

As Dr. Hollingsworth is present, it may be proper for me to mention a fact which that gentleman can corroborate, that Eng was the stronger physically and Chang was the stronger mentally. The same difference was observable in their characters. Chang was more irritable than Eng, especially since an attack of paralysis with which he had been afflicted,—this being in the side next to Eng.

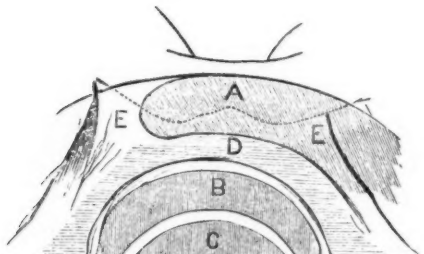

Fig. 3. Diagrammatic representation of the band. *A*, Upper or hepatic pouch of Chang; *E*, *E*, (dotted line), union of the ensiform cartilages; *D*, connecting liver band, or the "tract of portal continuity"; *B*, the peritoneal pouch of Eng; *C*, the lower peritoneal pouch of Chang; *E*, *E*, lower border of the band.

The latter had not only to bear with the irritability of his associate, but also to support one-half his weight. Among other peculiarities, Chang would sometimes break useful articles or throw them in the fire.

In conclusion, let me say that when I turned up the skin and superficial fascia of the H incision on the posterior part of the band, I was struck with the development and the strength of the abdominal aponeuroses. The fibres arched, interlaced, and developed into a strong fibrous band about a quarter of an inch wide, running around the median line, although there was no actual joint in the cartilage.

PROF. HARRISON ALLEN:

Mr. Chairman: I will probably best discharge the duty devolving upon me by at once proceeding to a somewhat more minute anatomical description than Dr. Pancoast has given, this being in accordance with the understanding between us in reference to the evening's exercises.

Perhaps it would be best to point to that simple diagram upon the blackboard before considering the subject more fully in detail. As Dr. Pancoast has informed the Fellows, there is a union of the twins at the two ensiform cartilages, which are very firmly joined in the centre, Eng's process being the more robust of the two. You will observe that there is a point of conjunction between the two processes which is not quite in the median line of the band. In the centre of the band is seen an elliptical space which suggests to the observer the presence of a synovial cavity. It is probable that the ensiform junction is of the character of a synchondrosis, with a median bursa-like sac; neither ensiform cartilage is ossified.

Below this point, in the diagram (Fig. 3), you see a number of differently-lined tracks. The lower one (C), immediately above the umbilicus, is only separated from the skin by a very delicate layer of tissue (so that, with the finger introduced into the pouch and moved, there is a decided indication of motion in the skin) on the under surface (EE, E) of the band.

This pouch passes across the band from the abdomen of Chang, and is lost in the duplicature of the suspensory ligament of the liver of Eng. The finger passed upward to the band from the abdomen of Eng crosses the band above pouch just mentioned, and is lost between layers of the suspensory ligament of the liver of Chang. When the significance of the round ligament at the free border of the suspensory ligament is remembered, the relations of these pouches directly suggest that they have had essential bearings to the umbilical vein of the funis, and may be provisionally termed the *umbilical pouches*. Above Eng's pouch (B), and between it and the under surface of the ensiform conjunction, is a second pouch (A) prolonged from Chang's abdomen, which fairly reaches the peritoneal cavity of Eng, but is not continuous with it. Extending up into this pouch from Chang's abdomen is a process which suggested to the Commission the possibility of the transit of hepatic vessels. This view was rendered more probable from the fact that a similar process passed up into the band from the liver of Eng. Accordingly, the plaster injection, colored by ultramarine, was thrown into a tributary of the portal vein of Chang, when it was observed that the fluid passed freely into the liver of Eng, as well as into some of the mesenteric veins proper. It is my own hypothesis that this bond of union (D), was the true hepatic tract; but in its present state, in the absence of evidence of any parenchymatous admixture about the vessels thus crossing the band, we prefer to denominate the transit as the *tract of portal continuity*.

In the fœtal condition it is very likely that this large space (A), the upper pouch, now continuous with the abdomen of Chang only, was entirely occupied by true liver-tissue, which, as maturity was attained, became smaller, and left an empty space. Hence I propose to call this upper pouch the *hepatic pouch*. The contraction chanced to be greater on Chang's side, in harmony, it may be, with other evidences of a weaker and less developed type, which is so apparent in many of the tissues of Chang. Now, with reference to the demonstration. As Dr. Pancoast has already informed you, the incisions in the abdomen were made in rather an exceptional manner. By reference to the parts it will be seen that the incision in either individual was located in such a way as to avoid the median line, since it was supposed from the peculiar position of the umbilicus that the remains of the hypogastric arteries would be found extending from the fundus of the bladder upward and onward along the entire length of the anterior wall of the abdomen. Besides, this incision would enable us, by continuing from below upward, to fairly open the abdomen and examine the cord, without violating the conditions by which the Commission was bound. The flap comprises the greater part of the abdominal wall, and can be best observed, from the position of the bodies on the table, in that of Eng.

You notice that the tissues are well supplied with fat; and this condition is very plainly in contrast with that of Chang. Eng's side of the band is well nourished; Chang's end of the band presents an entirely different aspect. Chang was an invalid, and the weaker half of this organism, with less strength in the abdominal walls, and in every way less tissue than was possessed by Eng. You can mark that distinction very plainly in the two halves of the band, proving, if we had no other means of proof, that there could not be any very intimate communication of vessels between them.

The first point worthy of notice is that of an isolated mass of adipose tissue, evidently sub-peritoneal, which is in the position of the usual umbilicus, namely, in the median line of the abdomen, about half-way up the anterior wall. This is strictly symmetrical, a similar point of about the same size being found in Chang.

Another fact equally well pronounced is that in Chang the bladder was found very much contracted and contained no urine; it was deep down in the cavity of the pelvis. That of Eng, however, was distended with urine; hence there was a contrast in the appearance of the umbilical fold in the two individuals, in consequence of the bladders.

My finger is now in the *umbilical pouch* of Chang (C). The motion is noticeable in the under surface of the band. On the side of Eng no such motion will be observed. I can very clearly see my finger passing between the two folds of the suspensory ligament. At this point it would perhaps be well to exhibit the drawings which have been made of the views which we have been able to obtain from this very limited incision. On looking up towards the band with the greatest possible stretch of tissue, we see the arrangement of the remains of the hypogastric arteries converging towards the band of union. In this lower diagram we show you the livers joined by what is supposed to be the *tract of portal continuity*. You will observe the limits are somewhat symmetrical. Here is the liver of Chang, with a foreshortened right lobe.

The remainder of the right lobe is deep within the abdomen and of course it has not been seen. Here is the fundus of the gall-bladder, and there the suspensory ligament, carrying the remains of the umbilical vein. When the finger is passed from Chang into Eng, it is received between the folds of the suspensory ligament of Eng. In Eng, the parts are essentially the same although you see more evidence of adipose tissue. Here is a little ligament aiding in the support of the liver, to whose convexity it is attached; it is not seen in Chang at all. You might term it an accessory suspensory ligament. When the finger is introduced behind the pouch, it is observed to terminate blindly, showing, we think, that it is adventitious, due to the presence of that suspensory ligament.

We find some vessels of the portal system even as far down as the mesentery, well filled with the blue coloring-matter. We of course desired, as far as possible, to examine all the tissues here by these incisions; hence it was that when the bodies were in this position the skin was taken off from the wall in order to get a view of the linea alba.

The bodies were here inspected by the audience, and afterwards turned so as to expose the posterior part of the band. Further remarks apply to this posterior aspect.

DR. PANCOAST:

While the bodies are being turned, I will take the opportunity of replying to one or two questions which have been asked me. First, in regard to the common sensibility of these two individuals. According to the statements we received at Mount Airy, there was a line of common sensibility corresponding to the median line of the band. Dr. Hollingsworth says that if a pin were stuck into the band at the median line, both of the twins would feel it distinctly; but that, even at the slight distance to either side, the point of the pin produced an effect only on the twin of that side.

Another question has been asked me, as to whether either of them was ever put separately under the influence of an anæsthetic. I answer it by saying that so far as we know it never was attempted but that when, upon the final occasion Chang was anæsthetized by death, Eng was for a time unaffected. The story as told at Mount Airy was that Eng waked up and asked his son, "How is your Uncle Chang?" The boy said, "Uncle Chang is cold—Uncle Chang is dead." Then great excitement took place. Eng commenced crying out immediately,—saying to his wife, whom they called in, "My last hour is come," and finally sank away. He was in perfect health when they went to bed.

They had been sitting up in a large double chair, made for their accommodation. Eng was smoking his pipe, until he became sleepy, and finally said to Chang, "We must retire." Chang said that he could not lie down comfortably. I understand that when they went from Chang's house to Eng's house [see editorial], where they died, it was against the direction of Dr. Hollingsworth; but with their usual stubbornness they persisted in riding in an open buggy. To return to the narrative of the night of their death, after Chang had refused to lie down, they walked about the house for some time, and even went out to the porch, and washed their hands and drank some water. It was about one o'clock when they went to bed. Then Chang died, some time between that and morning; his death not producing any immediate impression on Eng. It was only when the latter woke up and inquired about the condition of his brother, that he was at all affected.

As to the question, "What caused Eng's death?" I am not able to tell. The post-mortem which has been made does not show the condition of his lungs. Probably the valves of his heart were in a disorganized condition, and probably also the shock upon that weakened organ caused death.

DR. ALLEN:

In my opinion, Chang died of a cerebral clot. From inquiry at his home, I was led to believe that the lung-symptoms were not due to pneumonia; indeed, were not severe enough to have been so caused. The suddenness of the death, the general atheroma of the arteries, and the fact that there had been previously an attack of cerebral paralysis, all indicated that the death was of cerebral origin. Eng probably died of fright, as the distended bladder seemed to point to a profound emotional disturbance of the nervous system, the mind remaining clear until stupor came on,—a stupor which was probably syncopal. One thing to be settled in the making of our examination was to get the bodies in the best possible position, so that we could judge of the true nature of the band.

You will observe the great contrast between the anterior appearance of the band and its posterior aspect. When we suspended them face to face we conceived we had them in the proper position for study. On the posterior side there was a fold underneath the skin extending from the ensiform cartilage of Chang, passing over, crossing the median line, and inserted into the ensiform cartilage of the opposite twin, Eng. It was one of the objects of the examination to determine what was the nature of the fold. I judge it to be the linea alba; but I leave the Fellows to decide for themselves. I will also add that, because we had not the privilege of cutting the anterior portion of the band, we were obliged to cut down from the point of which I have spoken to get to the structure, and demonstrate these *culs-de-sac* from behind.

Here (referring to the casts), from this point the incision is horizontal about midway, and joined laterally by two oblique lines which were directed one upward and the other downward and outward, making a modified letter-H incision. Thus we got all the space we needed. When I raise the skin, we see the scar of the umbilicus in the superficial fascia; and on lifting the other flap we get a better general demonstration.

And now we come upon the point of interest, namely, the position of the band and its true nature. We have a diagram here. You notice on Chang's side that there is an

arrangement of interlacing aponeurotic fibres, marked here; and these fibres, starting in Chang, pass across the median line and are inserted into the ensiform cartilage of Eng. Turning the lower flap downward, the upper flap upward, and the two lateral tongues outward, the superficial fascia is exposed. This is abundantly supplied with adipose tissue on either side, but it is free from fat where it covered the band. Both the lower flap and the fascia are lost in the scar marking the position of the umbilicus. The same dissection exhibits the position of the lower pouch of Chang. Turning down the external oblique, the two recti, and the internal oblique muscles, the transversalis was exposed, the latter forming a very well-defined layer in Eng, with an interval between the ensiform cartilage and the inferior margin of the thorax. These were much less marked in Chang.

Turning forward this layer of fibres in Eng from without inward, the diaphragm is brought into view. Muscular fibres are conspicuous in this position. The peritoneum on either side is now fairly exposed. Incisions may now be made with a view of demonstrating the pouches of the band. The upper pouch of Chang is, you will observe, freely opened on its posterior aspect, and the vessels in the tract of portal continuity are seen to be well distended with the injecting fluid. A small artery is seen crossing beneath this tract of veins, and is probably a branch of the hepatic; but, whatever may be its origin, it evidently could have little effect in influencing the nutrition of parts beyond the band, and is probably retained within the band itself. The lower pouch of Chang reveals nothing which was not demonstrable from in front, and the same may be said of the single pouch of Eng; thus confirming our opinions of the construction of the band before the pouches had been opened from behind.

DR. ABRAHAM JACOBI, of New York, being called upon, said:

I am very much obliged to the gentleman who has mentioned my name. I do not believe, Mr. Chairman, that I have anything to add to the stock of knowledge in regard to the subject before us. If I were to answer the question as to how this monstrosity originated, especially whether they became connected after having been separate organisms, I should say that that idea has been given up by those whose opinions are entitled to weight. It is true that years ago such specimens were spoken of by D'Alton of Halle; and a number of others have alluded to the idea that two such individuals might in embryonic life become united simply by adhesion, the result of their being located together in the embryo. In truth, it appears to me that at that period such a thing might be possible; but of course the union would be a superficial one, not involving the deep organs.

We know that the first epidermis is formed about the end of the fifth week of embryonic life, and that after a time it is thrown off, so that the embryo of about seven or eight weeks is more loosely covered with the real epidermis than in the earlier period. The epidermis is thrown off a number of times until about the fourth month of utero-gestation, when it is finally perfected and remains intact. Now it is suggested that at those times when the epidermis is thrown off the connection takes place between the two individuals, —just as the connection takes place between the prepuce and glans, which we so often find adherent in the fœtus in a number of new-born children.

There are evidences, which we cannot forget, that such connections have taken place before the final epidermis is formed, and about the time one of the earlier coverings is being thrown off, at a period when the internal organs, frequently implicated in such monstrosities, are already formed. There are few double monstrosities so well developed as this one. I think the records of about four hundred monsters have now been collected in the books and journals; but very few are of such a complete nature as this. Everyone has heard of the Hungarian Twins, who lived to the age of twenty-one years, in the last century. Another pair of female twins, that travelled in Germany about two years ago, were described at the time, in the *Berliner Wochenschrift*. They were of a similar nature. There are two cases on record in which a division has been successfully attempted, but in those cases the connections were not so well developed as in the Siamese Twins. The connection was in the same neighborhood, but was only superficial,—of skin and subcutaneous tissue. One of the cases is recorded by Dr. Boehm (*Virchow's Archiv*). Fortunately, or unfortunately, I do not know which, they were his own children. They were of the female sex. He separated them immediately after birth. One lived three and a half days; and when the case was described in 1866, the other was five years old. In that instance the connection—three and a half inches long—extended from the ensiform process to the umbilicus. The other case is described as early as 1689, by the old German author, König.

As far as the origin of twin monsters is concerned, I am certainly of those who are not of the opinion that two individuals could get into such an intimate connection by growing together. Certainly the connection is an original one. I believe that the general opinion is now that one Graafian vesicle may have two ova, or one ovum have two nuclei; and these finally may, like the two vitelli of an egg, be closed together, surrounded by the same material, forming a single complete ovum; and thus it may be that the two are included in the same ovum. I think that this will explain also why the sex is always the same,—why they are always both male or both female. They are male in twenty or twenty-five per cent of the cases.

DR. H. C. WOOD here asked Dr. Jacobi a question in regard to the Biddenden Sisters [an account of whom will be found in another column of this journal], as to whether they had been reported in the works on monstrosities.

DR. JACOBI:

I do not know anything about that.

DR. PANCOAST stated that an account of those sisters was contained in a semi-popular book entitled "Lexicon Tetraglotton," published by Samuel Thomson, London, 1660.*

*The Editor of the *Times* is indebted to Dr. Pancoast for an opportunity of inspecting the work. The account of the Biddenden Maids is in a single sheet, and is evidently not a part of the original book, but has been pasted in it. In appearance it equals the body of the work in age, as shown by the color and condition of the paper; but of course it is impossible to decide with any accuracy when it was put in the book.

None of the Fellows desiring to say anything further upon the subject, on motion, the College adjourned.

On Thursday, February 19, the Commission continued the autopsy upon the Siamese Twins, and made some important discoveries. They found that the two livers, which were supposed to be joined only by blood-vessels, were one body; the parenchymatous tissue being seemingly continuous between them.

The so-called *tract of portal continuity* is apparently liver-tissue, but the point has not yet

been proved by microscopic examination. It will be remembered that Chang was said to be possessed of one more pouch than Eng. When the liver was removed, however, an upper hepatic pouch was found also proceeding from Eng, so that the band contained four pouches of peritoneum, besides liver-tissue. These disclosures show that any attempt during life to separate the twins would in all probability have proved fatal.

A copy of the preceding article was sent to Dr. H. H. Newman, emeritus professor of zoology, University of Chicago, and he has written me the following note:

"The points in the report that most interested me, as a specialist in the field of twins and twinning, were first, the striking differences between the two components, second, the somewhat indirect statement that one of the twins exhibited situs inversus viscerum, and third, the theories proposed as to the embryonic origin of the double monster.

"It is interesting that the students of this case regard the origin by fusion of two embryos highly improbable, but lean toward the view that two ovarian ova, each with its own nucleus, fused in the follicle. This theory seems unacceptable on two accounts. First, each nucleus would have to be fertilized by a separate sperm and this could half the time result in a male and a female; whereas double monsters are always of the same sex in a pair. Second, no such fused ovarian ova have been observed.

"I regard Siamese twins and such like anomalies as the products of incomplete fission of an originally single embryo. There is abundant evidence in support of this view."

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

THE text of the illuminating book,[1] *Histopathology of the Peripheral and Central Nervous Systems*, adheres strictly to the meaning of the title. The author's approach has been almost entirely an anatomical one; little clinical discussion has been introduced, and still fewer physiological facts. The textual material therefore accomplishes its aim without becoming a hodgepodge. Apparently the author believes the subject of nervous histopathology alone to be enough for one volume.

This book is not particularly an easy one to read. It is very closely written, without wasted space, words, or illustrations. If it is a bit laborious, it is because it is so packed with facts and covers such a large number of individual topics. No pathological entity known to the neuropathologist has been undeserving of at least brief discussion. But because the book is so well organized, and because careful division of pathological states in the brain, cord, and peripheral nerves has been attained, the book loses the heaviness, which might at first seem ominous, without becoming choppy or disconnected in thought.

The outstanding feature of the book is its concise but amply sufficient treatment of the inflammatory, toxic, and degenerative diseases of the brain and spinal cord, subjects known to be of great interest to the author. It would be difficult to find a more adequate description of the histopathology in these diseases, often so difficult to relate to one another, and the student should find the author's presentation clarifying.

This is a useful, informative book. Its illustrations are numerous and have been well chosen. A generous bibliography follows each chapter. JOHN MARTIN.

BORN in Texas Hugh Young[2] comes from a line of illustrious forebears. His grandfather, Colonel Hugh Franklin Young, was a famous Texas ranger. His father, at the age of 26, was commissioned a brigadier general, the youngest, so it is said, in the Confederate Army. His mother's two brothers were captains in Stonewall Jackson's regiment, and his maternal grandfather, Dr. Kemper, was a famous physician. It was in his workshop that Hugh Young became proficient in the use of tools.

His early childhood was spent in San Antonio, Texas. His education presents an interesting story. In kindergarten his interest in mechanics and art began under the guidance of his teacher, Miss Larner, of whom he speaks affectionately. This interest continued throughout his life.

Later Hugh Young attended the San Antonio Academy, a private school started by Dr. William B. Seeley, who instilled in him a predilection for Latin and Greek. He attended the Stanton Academy and due to the influence of Major Owens he became interested in the classics. At one time he thought he would like to study journalism, but soon gave up the idea for the study of medicine.

He entered the University of Virginia and received the degrees of B.A., M.A., and M.D. in 4 years, a truly remarkable achievement. After he graduated from the University he returned to San Antonio and began the practice of medicine. Once embarked on this venture he quickly realized his limitations and concluded that he needed advanced medical training, a decision which prompted him to pursue further studies at Johns Hopkins Hospital.

Dr. Young's early experiences at the hospital are very interesting, some are amusing. They illustrate his keen interest in the patient and his illness. Likewise his determination to secure an appointment on the house staff—at that time most difficult to obtain—is worthy of note. His story of the period when Osler, Kelly, Welch, and Halsted were in the process of building up the medical school and their great interest in the younger men, and his description of the operating-room technique used then are illuminating.

One day in October, 1897, while walking down a corridor, he almost collided with Dr. Halsted and apparently was very much embarrassed. Dr. Halsted paid slight, if any, attention to his discomfiture, and there and then apprised him of the fact that he and Dr. Welch had decided that he should take over the department of genito-urinary surgery. Young remonstrated, saying he knew nothing about the subject, but Halsted replied that they were fully aware of this but believed he might learn.

Thus began a very interesting, productive, and fruitful career. Once he received the appointment he set about to master the subject. This resulted in journeys to Europe where he visited the various clinics and interviewed prominent urologists of the old world. Great credit is due Dr. Young for his important rôle in developing the specialty of urology.

Dr. Young's interest in instruments was probably due in part to his early mechanical training. One of his early cystoscopes had a retrograde vision and rather proud of his achievement he showed it to Dr. Nitze, the father of the cystoscope. The tongue

[1] HISTOPATHOLOGY OF THE PERIPHERAL AND CENTRAL NERVOUS SYSTEMS. By George B. Hassin, M.D. 2d. rev. enl. ed. New York: Paul B. Hoeber, Inc., 1940.

[2] HUGH YOUNG—A SURGEON'S AUTOBIOGRAPHY. New York: Harcourt Brace & Co., 1940.

lashing he received from Dr. Nitze must have been a severe one. Nevertheless, thoroughly undaunted, he held his ground with Dr. Nitze and a fist fight almost resulted.

Dr. Young's war experiences were wide and intensive. He describes the program for combating venereal diseases, skin diseases, and infestations by various forms of animal life. Directly the program for the control of these diseases was established, Dr. Young carried it out in all its details. Mastery of the venereal disease problem resulted in rendering aid not only to soldiers but also to the civil population.

With a dynamic personality such as Dr. Young possessed, it was natural that he should have many interests outside the practice of urology. Thus in the winter of 1903 he took an active part in the legislation for the prevention of tuberculosis. Despite the interest of the Baltimore newspapers in the matter and their intelligent presentation of the question, and after committees of prominent physicians, such as Osler, Welch, Thayer, and others, had appeared before the Legislature in favor of the bills, they were defeated. Not in the least daunted by this setback, Dr. Young, singlehanded, tackled the problem and succeeded in having the bills passed.

We next find him aiding legislation for the care of the insane in Maryland, and for many years he was the chairman of the lunacy commission. Later on when the City of Baltimore needed a municipal hospital he again took an active part in obtaining the necessary legislation.

Dr. Young, always greatly interested in aviation, was one of the early airplane riders, and when the Maryland State Legislature created an aviation commission he was asked by his great friend, Governor Ritchie, to select members for the Commission, of which he became the first chairman. Other legislative activities included the "Purse-Netters" Bill and the Potomac River Bill. Recently he took an active part in preparing the exhibit for Maryland at the New York World's Fair.

He devotes 129 pages to the description of various urological instruments and surgical technique—a questionable procedure perhaps in a book intended for lay reading. The *Autobiography* reflects an interesting personality. Its style cannot fail to hold the reader's attention since it abounds with those enviable qualities—candor and simplicity.

HERMAN L. KRETSCHMER.

THE author of *A Manual of Otology, Rhinology and Laryngology*[1] follows the usual plan in dividing the subject into its four main parts. The anatomical descriptions are given at the beginning of each part and are followed by discussions of the etiology, symptoms, diagnosis, and treatment. While concise, the descriptions are clear and adequate, and the many illustrations are a great addition. The entire field is covered so well that it is difficult to select any outstanding part.

Osteomyelitis of the skull is well described by the method of taking each bone separately. A good comprehensive understanding of the subject is given in a few pages.

Functional hearing tests are carefully described and illustrated; so interpretations as to the type of deafness can be made with ease. The same applies to the functional tests of the labyrinth. Here the author includes an excellent, illustrated chart showing the vestibular reactions.

This book is an outstanding textbook of its type and should find a warm welcome with the undergraduate medical student and the general practitioner.

LINN F. MCBRIDE.

LONG awaited, the radiological world gladly welcomes the appearance of the guide to the anatomical and roentgenological study of the head and neck by Pancoast and Pendergrass.[2] This work of nearly 800 pages, with over 1,200 illustrations, is most comprehensive. It is difficult to indicate any sections of unusual excellence; the entire work is a triumph of modern medical radiology, constituting a principal source of information on the radiological aspects of the head and neck for physicians, surgeons, and specialists who wish expert knowledge concerning the diseases, injuries, and anatomical variations of this part of the body. Praise must be voiced for the excellence of the illustrations, including a number of excellent anatomical drawings, displaying new aspects of anatomy as well as new information. Every possible phase of head and neck disease, injury, and anatomical variation is recorded, including radiology of the teeth and the localization of foreign bodies in the eye.

JAMES T. CASE.

THE third edition of *Pathology*[3] appears, according to the author's preface, in two forms: as a separate textbook, the book now being reviewed, and bound together with a textbook on microbiology written in collaboration with Mrs. Jean Martin White (Piette and White: *Microbiology and Nursing*, F. A. Davis Company, 1940).

The present edition of *Pathology* is in four units: general pathology, special pathology, tumors, and autopsies and clinical pathology. These comprise 18 chapters, and 229 pages of text, quarto. The indexing is good. There are 60 illustrations, almost all reprinted from other authors, none in color, (4 are partially colored), many of them apparently from drawings, and without explanatory pointers or labelling. These are almost without exception of very indifferent quality, and it is doubtful that they would mean anything at all to the student nurse, for whom this book is written, since they signify but little to an experienced pathologist. It is probable

[1] A MANUAL OF OTOLOGY, RHINOLOGY AND LARYNGOLOGY. By Howard Charles Ballenger, M.D., F.A.C.S. Philadelphia: Lea & Febiger, 1940.

[2] THE HEAD AND NECK IN ROENTGEN DIAGNOSIS. By Henry K. Pancoast, M.D., Eugene P. Pendergrass, M.D., J. Parsons Schaeffer, M.D., Ph.D. Springfield, Ill., and Baltimore, Md.: Charles C. Thomas, 1940.

[3] PATHOLOGY. By Eugene C. Piette, M.D. 3d ed. Philadelphia: F. A. Davis Co., 1940.

that these illustrations are not worth the space they occupy. (It is but just to add that most are captioned with good explanatory notes in fine print.)

Each chapter is prefaced by an outline of its contents and concluded with a set of review questions. Both add distinctly to the usefulness and clarity of the text.

At the end of each chapter references are cited; these are largely a repetitious listing of the standard texts of pathology used in medical schools, and found on every pathologist's shelves. Since no page references to the subjects referred to are included, it is hardly to be expected that the student nurse will profit by the inclusion of these references. Space would be saved if most were omitted and unless page references were indicated, the list might certainly better be consolidated at the end of the book.

Most of the above criticism is of an adverse nature. The text, however, is written simply and covers economically and clearly as much of pathology as the nursing school curriculum permits. The textual portion of the book is excellent. The typography is large and lends itself to comfortable reading. Pedagogically the text could be improved by the addition of more short illustrative case reports (such as is cited on page 158), particularly those illustrative of the more important lesions.

The present reviewer considers this a good book, which will continue satisfactorily to fulfill the use for which it was written, namely, as a text of pathology for student nurses. It is succinct, practical, and clear. Because the text is good the book deserves to be improved by illustrations of a quality which will complement the text. FRANK B. QUEEN.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

FRACTURES AND DISLOCATIONS FOR PRACTITIONERS. By Edwin O. Geckeler, M.D. 2d ed. Baltimore: The Williams & Wilkins Co., 1940.

A SURGEON'S LIFE; THE AUTOBIOGRAPHY OF J. M. T. FINNEY. New York: G. P. Putnam's Sons, 1940.

THE DIAGNOSIS AND TREATMENT OF DISEASES OF THE HEART. By Henry A. Christian, M.D., Sc.D. (Hon.), LL. D., F.A.C.P., Hon. F.R.C.P. (Can.). (Reprinted from *Oxford Monographs on Diagnosis and Treatment*). London, New York, Toronto: Oxford University Press, 1940.

HYDROCEPHALUS; ITS SYMPTOMATOLOGY, PATHOLOGY, PATHOGENESIS AND TREATMENT. By Otto Marburg, M.D. New York: Oskar Piest, 1940.

THE 1940 YEAR BOOK OF PATHOLOGY AND IMMUNOLOGY. PATHOLOGY edited by Howard T. Karsner, M.D. IMMUNOLOGY edited by Sanford B. Hooker, A.M., M.D. Chicago: The Year Book Publishers, Inc., 1940.

THE 1940 YEAR BOOK OF INDUSTRIAL AND ORTHOPEDIC SURGERY. Edited by Charles F. Painter, M.D. Chicago: The Year Book Publishers, Inc., 1940.

L. EMMETT HOLT; PIONEER OF A CHILDREN'S CENTURY. By R. L. Duffus and L. Emmett Holt, Jr. New York, London: D. Appleton-Century Co., 1940.

SURGICAL ANATOMY OF THE HEAD AND NECK. By John Finch Barnhill, M.D., and William J. Mellinger, M.D. 2d ed. Baltimore: The Williams & Wilkins Co., 1940.

PSYCHIATRIC DICTIONARY; WITH ENCYCLOPEDIC TREATMENT OF MODERN TERMS. By Leland E. Hinsie, M.D., and Jacob Shatzky, Ph.D. London, New York, Toronto: Oxford University Press, 1940.

DIE UROLOGIE IN EINZELDARSTELLUNGEN. Edited by Prof. Dr. H. Boeminghaus. GANG UND TECHNIK DER ROENTGENUNTERSUCHUNG AUF HARNSTEINE. By Dr. Eduard Pflaumer and Dr. Hermann Friedrich. Leipzig: George Thieme, 1940.

CORRESPONDENCE

SURGICAL AND MEDICAL SUPPLIES NEEDED FOR GREAT BRITAIN

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